1952

Tests of a1:32 model of a proposed outlet structure for first fork (sinnemahoning) dam, for Gannett, Fleming, Corddry and Carpenter, Inc., June-September, 1952.

M. B. McPherson

H. S. Strausser

(B 33)

237.51

To W. J. Eney
with thanks for
professional advice
and assistance.

TESTS OF A 1:32 MODEL

OF A

PROPOSED OUTLET STRUCTURE

FOR FIRST FORK (SINNEMAHONING)

DAM

by

M. B. McPherson and H. S. Strausser

For

Gannett, Fleming, Corddry and Carpenter, Inc.

Harrisburg, Penna.

Fritz Engineering Laboratory
Department of Civil Engineering and Mechanics
Lehigh University
Bethlehem, Penna.

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June-September, 1952.

T A B L E   O F   C O N T E N T S

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LIST OF FIGURES (continued)

I--INTRODUCTION

After preliminary correspondence, a letter dated May 8, 1952 from Mr. A. E. Niederhoff of Gannett, Fleming, Corddry and Carpenter, Inc. gave a general authorization to initiate model tests on the First Fork Outlet Structure. The tentative testing program was discussed at a meeting on May 14 by Professor W. J. Eney, Head of the Department of Civil Engineering and Mechanics and Director of Fritz Laboratory, Mr. Niederhoff and the writers.

Details of the Original (Preliminary) Design are shown in Figures 1 through 4. A hydraulic analysis of the original design indicated that several features were undesirable. On May 30 during a meeting with Professor Eney and the writers, Mr. Niederhoff requested Lehigh to prepare details of a model to be substituted for the preliminary design. The following requirements were stipulated for inclusion in the revised design: (1) A single, sixteen-foot diameter conduit, (2) a discharge of 13,000 cfs at the overflow spillway crest, El. 1026, (3) retention at all times of a Conservation Pool at El. 920.0, (4) permit a construction bypass through the conduit of 4,300 cfs at as low a pool level as possible. In addition, it was desired that negative pressures would not occur in the outlet and conduit and that an efficient stilling pool could be determined for all rates of flow. (The 250-foot wide overflow spillway was not involved in this test program.) Pursuant to the requirements outlined above, the model design given in Figures 5 through 8 was completed on June 13. Approval to build a model having the features detailed in Figures 5 through 8, and hereinafter referred to as the Revised Design, was given by Mr. Niederhoff on June 16.

The Revised Design was considered by the writers to be the safest combination embodying the requirements set forth above so long as both service gates were used only to dewater the conduit or for emergency closure in the event of conduit defection. It is the writers' opinion that satisfactory operation, in terms of serious cavitation, cannot be attained at partial gate openings, at heads exceeding about 70-feet, under the limiting requirements for this structure.

Construction of the model was completed on July 22 when a trial run was made. The operation of the model was observed by Mr. Niederhoff, Mr. N. C. Courtney of Justin and Courtney, Philadelphia, and Mr. V. P. Connelly of the General State Authority on July 25.

II--THE 1:32 MODEL-GENERAL

The model described in this report was constructed on a scale of 1 to 32, to the dimensions indicated in Figures 5 through 8. Model photographs showing general details are given in Figures 9 through 13. In this report all quantities refer to prototype values unless specifically identified with the model. In order that the head loss, particularly in the conduit, of the model would be close to the scaled anticipated loss for the prototype, it was necessary to employ an extremely smooth conduit material. The most satisfactory smooth material is Lucite or Plexiglas tubing which comes in a maximum inside diameter of 5-5/8" with a 1/4" wall. To obtain an even scale ratio it was necessary to have this tubing expanded to an even 6". The scale ratio was thus fixed at a maximum of 1 to 32, while a larger scale of about 1 to 25 would have been hydraulically more satisfactory but not absolutely essential. From past experience the functioning of this 1:32 scale model would result in an equivalent prototype Manning's "n" of 0.014 or a Darcy friction coefficient "f" of 0.015. A model scale of 1 to 25 would have required a model having an overall length of close to 70', and the increased discharges would have been more difficult to handle.

The conduit was laid on the same slope as that indicated in both the Original and Revised plans: 0.00905. This slope is greater than critical, resulting in supercritical flow for nearly all open flow depths.

Thirty-six piezometers were installed in the gate chamber area and nine in the conduit proper. The majority of gate chamber taps were concentrated in the Left chamber (looking downstream). The taps in the Right chamber were installed to check on equal discharge distribution through the two gate chambers. The conduit taps were all located at the invert. The chamber taps were located on centerlines in the four surfaces. These latter taps were situated in such positions as would provide data giving average conditions and the approximate local conditions. The location of local points of low pressure inducive to cavitation would not have been feasible, since a larger number of taps would not guarantee complete coverage of all critical points.

The depths over the forebay spillway were measured with a hook gage having a smallest division of 0.001'. Model reservoir pool elevations above El. 940. were measured with a piezometer accurate to the nearest 0.005'. The tap piezometers were read to the nearest 0.005'; any fluctuations in readings with time of magnitudes ± 0.02' were ignored, and the range of larger fluctuations was recorded as such. Model forebay depths were recorded the equivalent of 10-20' upstream from the intake, and read to the nearest 0.01'. Depths recorded in the model stilling pool were accurate to at least the nearest 0.05'. Measurement of stilling pool and forebay velocities were made whenever physically possible.

The discharge was measured by means of a calibrated venturi meter. Discharge measurements equivalent to 4,000 cfs or greater are accurate to within less than one-half a percent. For the readings at 2,000 cfs, the errors involved in reading the venturi manometer might have been as great as 15%.

III--THE 1:32 MODEL-BOTH GATES OPEN.

The model was designed to operate with both gates open. Since partial gate openings were not pertinent, no gates were installed, although it might have been well to have included gate openings in the soffit of the model. The water levels for the revised design are tabulated in Figure 14, and plotted in Figure 22. In Figures 15 through 19 are itemized the data for Runs 1 to 3 and 7 to 13. Since the pressure, or pressure head at a given point is more pertinent in terms of possible cavitation than the piezometric head, all tap data is given in terms of the pressure head relative to the given tap.

No negative pressures in the gate chamber area or transition are indicated. At the point where the gate chamber is just flowing full (around 3,000 cfs) soffit pressures may be very slightly negative; measurements of soffit pressures for this condition were not made since air drawn from the intake and the vents interfered with the readings.

No negative pressures are indicated in the conduit invert. When the conduit is flowing full (more than 4,300 cfs) negative pressures would occur at the soffit near the exit; for discharges greater than 8,000 cfs, negative pressures would occur in the conduit soffit within the last 350' of length. Although the overall probable negative pressures near the exit will not exceed about 5-feet, it should be noted that the conduit velocity head is about 25' at a discharge of 8,000 cfs. In brief, any misalignment within the last third of the conduit would most certainly lead to cavitation in that vicinity.

In Figure 20 is a plot of the piezometric head along the floor and inverts. Wall and soffit taps at similar stations do not differ appreciably from the readings shown. A comparison of piezometric heads at various stations has been made in the plots of Figures 47 to 55. It may be noted from the data of Figures 15 to 19 and the plot of Figure 20 that the hydraulic grade line in the conduit is non-linear in the lower half of the conduit, there being a small back pressure caused by the slight change in slope from the end of the conduit to the tangent of the stilling pool vertical curve. Since the end of the conduit is not perpendicular to the centerline, the resulting elliptical shape of the opening may have some influence on the location of the point of zero pressure.

IV--SIMILARITY AND THE 1:32 MODEL

Forces of Friction, Inertia, Gravity and Pressure are the predominant forces involved in this design. Surface Tension should have little effect except at the lowest rates of flow. Complete similarity requires that all forces involved in the prototype be duplicated undistorted in the model. Complete similarity is seldom if ever attained in a model. Approximately complete similarity is approached by taking advantage of special instances in which one group of forces predominates, or where other forces are negligible or small in contrast. In the stilling pool, Inertia and Gravity far outweigh the effects of Friction. In the forebay, the action of the submerged hydraulic jump is dominated by Inertia and Gravity and the Friction along the walls and bottom are comparatively insignificant; provided the head over the spillway exceeds about two-tenths of a foot, the effects of Surface Tension are negligible.

In the conduit, on the other hand, at flowing-full conditions Friction is the predominant force, along with Pressure. In this model, to compromise the conflicting velocity requirements of Inertia-Friction, or Reynolds similarity, and Inertia-Gravity, or Froude similarity, the discharge was used which would satisfy Froude similarity, and the model conduit head loss was made similar to that for the prototype by using a smoother conduit material, even though the Reynolds numbers were not identical. For Froude similarity the discharge is proportional to the scale ratio to the five-halves power. For a 1:32 scale model the model discharge is therefore 1/5,800 of the prototype. Using these rates of flow, the action in the stilling pool and forebay of the model represent very closely the effects to be expected in the prototype, except at the lower rates of flow.

As mentioned previously, the model was designed for an equivalent prototype Manning "n" of 0.014 or a Darcy "f" of 0.015. In Figure 21 are itemized the components of the total head between the Reservoir Pool and El. 889., the centerline of the conduit at exit. It was anticipated that the friction coefficient "f" would vary between about 0.0158 to 0.0148, but not so low as the 0.0138 indicated. These friction factors were computed on the assumption that the vertical curve at the end of the conduit, in the stilling basin, would not affect the free jet at the exit of the conduit. The data of Figures 15 through 19 and the plot of Figure 20 show that this was not quite the case. The effect of the stilling basin vertical curve is to raise the point of zero pressure at the exit to a point above the centerline. This does not in itself affect appreciably the pressure conditions at the exit, but does explain indirectly why the discharge is greater than anticipated at the higher heads (or why the "apparent" friction factor is lower than it should be).

As a convenience in approximate calculations, for discharges greater than 8,000 cfs; multiplying 1,140 times the differential head between the reservoir pool and El. 889 to the one-half power will provide values close to those plotted in Figure 22.

The total loss due to the gate area and transition is quite small, and may be closely approximated by 0.075 times the differential head between the reservoir pool and El. 889.

The discrepancy between model and predicted prototype discharge is not significantly great: a discharge of 13,000 cfs occurred at El. 1019. rather than at the predicted prototype pool elevation of 1024.

As a matter of record, the relative roughness of the model was an e/D of approximately 0.0001. The predicted prototype discharge was based on the assumption of a prototype relative roughness of 0.0003.

V--AIR VENT PERFORMANCE

An air vent was mounted on each of the two gate chamber vent slots, as may be seen in Figure 12. It was planned to measure the air demand by means of an orifice meter in the air vents, but the amount of air which was involved was much too small. With both gates open a very small amount of air (approximately the same amount, and under the same conditions, as the air drawn from the intake) was drawn into the gate chamber at discharges between 3,000 and 5,000 cfs. (Refer to Figure 14.)

A comparison of the water level in the vents and the pressure head in nearby soffit taps is made in Figure 23, with all data referenced to El. 906.

As will be presently outlined, certain runs were made without the forebay and weir. Reference to Figure 32 will show that conditions without the forebay were very similar to those with the forebay.

VI--THE 1:32 MODEL--RIGHT GATE CLOSED.

In an effort to demonstrate the dangerous conditions which would occur were one gate closed, the Right service gate (looking downstream) was completely sealed by inserting a fitted plate across the gate slots. Only three runs were made, by way of comparison. The data for these runs is given in Figure 24. Runs R-1 and R-3 were made with both vents open, operating normally. Run R-2 was at the same discharge as Run R-1, except that the two air vents were completely sealed. At the same discharge, Runs R-1 and R-2 show the relief, in terms of negative pressures, afforded by the air vents. In Runs R-1 and R-3 very little air was drawn from the Left vent, whereas a very substantial amount was drawn from the Right vent. With the vents open, the high velocity of flow confined to the Left chamber caused an oscillating open channel flow at about 0.8 depth even for Run R-3, at 11,400 cfs. The flow for these two runs left the end of the splitter wall in a spiral which entrained air and did not substantially dissipate before reaching a point about 100 feet beyond the end of the splitter; the water in the right section below the gate was completely removed by the live stream from the Left chamber. The water levels in the tap piezometers fluctuated at nearly all positions for all three runs. In Run R-2, with the vents closed, the area between the right closed service gate and the conduit was filled with water.

There is no doubt that serious surging and at least some cavitation would occur in the prototype if for some reason only one gate was open. Steel lining in the gate chamber would not necessarily provide adequate protection under this circumstance.

VII--FOREBAY CHARACTERISTICS.

Photographs of the forebay at various rates of flow are given in Figures 25 to 31. Water levels in the forebay are included in Figure 14. The hydraulic jump in the forebay was submerged at all rates of flow. The water surface was level for a distance of about 60 to 75 feet upstream from the intake, to a point which was essentially the end of the hydraulic jump. Violent agitation was confined principally to the region of the jump itself. Velocity measurements were attempted in the forebay. The maximum average approach velocity occurs at about 5,000 cfs, which would be about four feet per second in the prototype and only three-fourths of a foot per second in the model. This velocity is too small to be measured accurately. Measurements made with a midget current meter indicated velocities in the vicinity of the axis of symmetry and about eight feet upstream from the intake to be approximately equal to the average cross-sectional velocity. No velocities measurably different from the average were noted within fifty feet of the intake. Since reversal of flow upstream from the intake, caused by the residual eddies from the jump, invalidated most meter readings, more reliability was placed on feeling the flow throughout the area near the intake. No regions of high velocity, for discharges up to 8,400 cfs were noted. Occasionally small eddies from the jump were carried near the intake but were soon dissipated.

Provided normal flows did not hover in the vicinity of 3,000 to 5,000 cfs, and that this flow rate range would be passed through quickly, the operation would be without incident, except for some noise caused by the collapsing of air taken in at the intake and vents. This range could be lowered or raised by changing the slope of the conduit.

VIII--REVISED DESIGN WITHOUT FOREBAY

The testing program of the revised design was to have included experimentation with the forebay to determine the shortest length in which a uniform and low velocity could be obtained at the intake. The tests with the forebay of arbitrary length detailed in Figure 6 indicated that the length from the toe of the spillway to the intake could be shortened from 119' to perhaps 70', and perhaps shortened substantially more with the employment of sills at the apron of the spillway.

On 31 July, Mr. E. B. Philips and Mr. J. H. Turner of Philips & Davies, Inc., gate specialists from Kenton, Ohio, Mr. Niederhoff and Mr. Easton of the sponsoring firm and Mr. Courtney witnessed the operation of the model. The discussion of this meeting centered around the possibility of operating the proposed service gates at partial opening at least under low heads so that the relatively expensive construction involved in the forebay could be avoided. A letter dated 1 August from Mr. Niederhoff ordered removal of the forebay and spillway with tests to be performed on the submerged inlet with both gates wide open.

In Figure 32 are tabulated the water levels for these runs. The data on the complete runs made is given in Figures 33 and 34. A plot of water surface levels with and without the forebay are included in Figure 35.

Stage-discharge relations with or without the forebay were virtually identical. The pressure head values without the forebay tended to be very slightly less in general than those with the forebay, with a maximum difference for any given stage-discharge combination of about three feet (prototype equivalent).

There is no significant hydraulic difference, therefore, between the two arrangements.

Even though the steel lining extends well below the gates, great care should be exercised in insuring full gate openings at medium to higher heads. At the partial gate openings tentatively under consideration by the sponsors a limit might logically be set at an average gate chamber velocity head of 20' which would exist with both gates open at a discharge of 9,200 cfs and a total differential head of 68'. This is also a practical limit, since operation with partial gate openings is often unsatisfactory and seldom recommended for heads in excess of 75'. A safer limit might be a point just beyond full conduit flow at a discharge of 5,800 cfs and a head of 30'. This latter is the conservation pool level. It is therefore evident that very careful gate operation should be required. It should not be too difficult to restrict partial gate operation to safe heads of 25 to 35 feet for the purpose of maintaining the conservation pool; at partial gate openings the entrapment of air should no longer occur. The exact head at which cavitation would become dangerous at partial gate openings cannot be predicted from the present studies with any degree of certainty.

IX--ORIGINAL AND REVISED STILLING POOL

The objective of the stilling basin tests was to check the original design and to make as many improvements as possible on this design without altering basic features. A tailwater rating curve was not available and the economic limitations as to extension of the depth or length of the basin was indeterminant at the time of these tests, completed on 31 July. Two minor changes from the original design were made in the model; the curve of the tapered walls at the exit of the conduit (Figure 4) was replaced by two almost equivalent chords as may be seen in Figure 36, and the equivalent earth slopes at the end of the pool of 1 on 1 with a transition to 1 on 2 were replaced with a continuous slope of 1 on 2. No attempt was made to regulate the tailwater since these tests were deemed purely exploratory.

<u>Original Design Stilling Basin</u> (See Photograph--Figure 37)

Observations of the performance of the original stilling pool are itemized in Figure 46. As indicated, the original walls were too confining, for the estimated maximum tailwater at El. 892 of 27' was equalled or exceeded beyond 6,500 cfs. The high-velocity jet at the end of the vertical curve and the entrance to the pool floor continued practically undiminished through the pool for all medium to high rates of flow. The pulsations in this live fast stream made velocity measurement impossible (model conduit velocity at equivalent of 13,000 cfs was 11.4 fps). The sills located in the vertical curve tended to throw the jet above the line of sills on the floor, resulting in a concentration of very high velocity at the end sill. Since the jet continued to the end sill practically undiminished in velocity and cross-sectional area with a tailwater level higher than the maximum estimated, it was felt that any attempt to use more floor sills and/or a different arrangement of sills would provide little improvement unless the pool was deepened and/or lengthened. Since the original design walls created an unmanageable disturbance in the model (splashing), the revised design walls were installed without delay. The action of the original pool at 12,000 and 13,000 cfs is shown in the photographs of Figures 38 and 39.

Revised Design Stilling Basin (See Photograph--Figure 40)

Flaring the training walls was considered by the writers to be a nominal revision. Anticipating difficulties with the original walls, revised walls shown in Figure 36 and illustrated in the photograph of Figure 40 were made in advance. These walls double the width at the end sill, and form a continuous line with the downstream chord of the tapered walls at the vertical curve.

The general characteristics of this arrangement were first investigated by removing all floor and vertical curve sills, leaving only the exit weir sill. Widening the exit appeared to decrease the velocity of the jet as it passed over the end sill, and the cross-sectional area of the jet at the sill was increased and elongated.

A series of trials were made using the original design sills first with, and then without, the sills in the vertical curve. Little if any additional dissipation was noted, and the jet skimmed over the floor sills. The velocity at the end sill near the bottom was very high.

The vertical curve sills were removed and the original pool sills were augmented by as many as two additional rows in various arrangements. There was no noticeable improvement with more than one row of sills over a single row, regardless of arrangement.

Without resorting to a major change in the design it was then concluded that the basic objectives should be to spread the jet as uniformly as possible and raise the maximum velocity points at the end sill as high above the sill as possible. To accomplish these immediate objectives the floor sills were reversed in direction, with the sloping face upstream as shown in Figure 36. It was hoped that this arrangement would deflect part of the jet vertically with consequently increased roller action.

Reversing the sills was effective in raising the jet off the floor. Several combinations were tested. It was found that the floor sills had to be located in the central portion of the width to obtain a more uniform velocity distribution; sills near the walls merely concentrated the jet. The most effective pattern was that detailed in Figure 36. The leading row of sills (two), although not desirable from an erosion standpoint, was absolutely essential in dissipating the jet. Since this design was not completely satisfactory, complete velocity traverses were not made, but the point of maximum velocity was determined and recordings made of the maximum velocity at various rates of flow as recorded in Figure 46.

The revised stilling pool shown in Figure 46 represents close to the best arrangement which can be obtained without lowering the floor (probably a substantial amount-in rock) and/or materially lengthening or reshaping the basin.

X-SUMMARY AND CONCLUSIONS

Tests of 1:32 Model--To 9 August 1952

A. Both Gates Open:

For this condition, the model performed satisfactorily. No negative pressures of any consequence were noted in the gate chamber or transition at any head. In the conduit, negative pressures would be encountered at the soffit within the last third of its length when the discharge exceeded 8,000 cfs (conduit velocity head =25'); therefore, misalignments in this region would surely result in cavitation damage nearby. The slope of the hydraulic grade line is proportional to the discharge and the distance over which negative pressures occurred in the model was therefore least for the maximum discharge, as may be seen in Figure 20.

Some instability was noted in the flow when the discharge ranged from 4,000 to 4,300 cfs. Both with and without the forebay, standing waves and/or a hydraulic jump might possibly form in the conduit at this stage; however, this point could be passed in a short time without serious results.

Air was trapped and carried into the flow at the entrance during the transition from open channel to full flow (water level at entrance El.906 to El.912) the primary cause of the air entrainment being the roughness of the approach water surface. Without the forebay, this condition lasted for a shorter period because of the quieter surface.

B. Right Gate Closed:

As determined from the model tests, cavitation of a dangerous nature would quite likely occur in the event that only one gate were open. Quite high negative pressures were recorded for this arrangement and also disturbed flow was observed in transition and conduit. The water leaving the left passage had a spiral motion which did not dissipate until well into the conduit. The conduit itself did not flow full even for a discharge of 11,400 cfs. Operation with one gate closed is inadvisable.

C. Model with and without Forebay:

The forebay and weir upstream from the intake was intended to maintain the conservation pool. The model tests with forebay in place and discharges in the vicinity of 3,000 to 5,000 cfs indicated that the air taken in at the intake and vent would cause some noise by its collapse; therefore, it would be advisable not to maintain discharge at this stage for too long. This condition occurred without the forebay but over a smaller range.

No appreciable difference was noted in the outlet pressures with or without forebay.

D. Gate Operation:

The model was designed to be operated with both gates entirely open. The tests have indicated that operation with one gate closed would be dangerous.

The present model tests do not warrant predictions as to just what head would cause serious cavitation at partial gate openings. If it is decided to maintain the conservation pool by means of gates, operation of same should be symmetrical. For total differential heads in excess of 68' (discharge = 9,200 cfs) and an average gate chamber velocity head of more than 20', gates should be fully open. The gates could be fully open at a discharge of 5,800 cfs, which is the capacity for maintaining the conservation pool at El. 920. Partial gate openings could be restricted to heads of 25 to 35 feet without difficulty.

E. Stilling Pool:

At present, the testing of the stilling basin is inconclusive. The revised pool is not entirely satisfactory, even though the altered walls spread out the area of the jet and the reversed sills raise the high velocities off the floor. Further testing and alteration are contemplated upon receipt of a tailwater curve and the results of an economic survey.

XI--ACKNOWLEDGEMENTS

The writers wish to thank the following engineers for their cooperation and suggestions during the testing program and demonstrations at Fritz Laboratory: Mr. Niederhoff and Mr. Easton, of Gannett, Fleming, Corddry and Carpenter; Mr. Courtney, of Justin and Courtney; Mr. Connelly, of the General State Authority; Mr. Philips and Mr. Turner, of Philips and Davies.

Special appreciation is due Professor W. J. Eney for his helpful professional and administrative advice.

The model was run for Messrs. Hooke, Li and Pickering of Gannett, Fleming, Corddry and Carpenter on July 30. A special demonstration run was made for Professor G. E. Barnes of Case Institute of Technology on the 6th of August.

All machining of the gate chamber and splitter was performed by the Bethlehem Foundry and Machine Company. Final polishing and the fabrication of several components were done by Mr. Green, of the Plastic Mart in Allentown. The conduit and transition were fabricated by Mr. Van Gaasbeek, of Van Beek Industries, Orange, New Jersey. All wooden components were made by Mr. Wieand, of the University carpenter shop. All photographs in this report were taken by Mr. K. Harpel, of the Fritz Laboratory shop.

All tests for this project were conducted in the Hydraulic Laboratory of the Department of Civil Engineering and Mechanics' Fritz Laboratory at Lehigh University, Bethlehem, Pennsylvania.

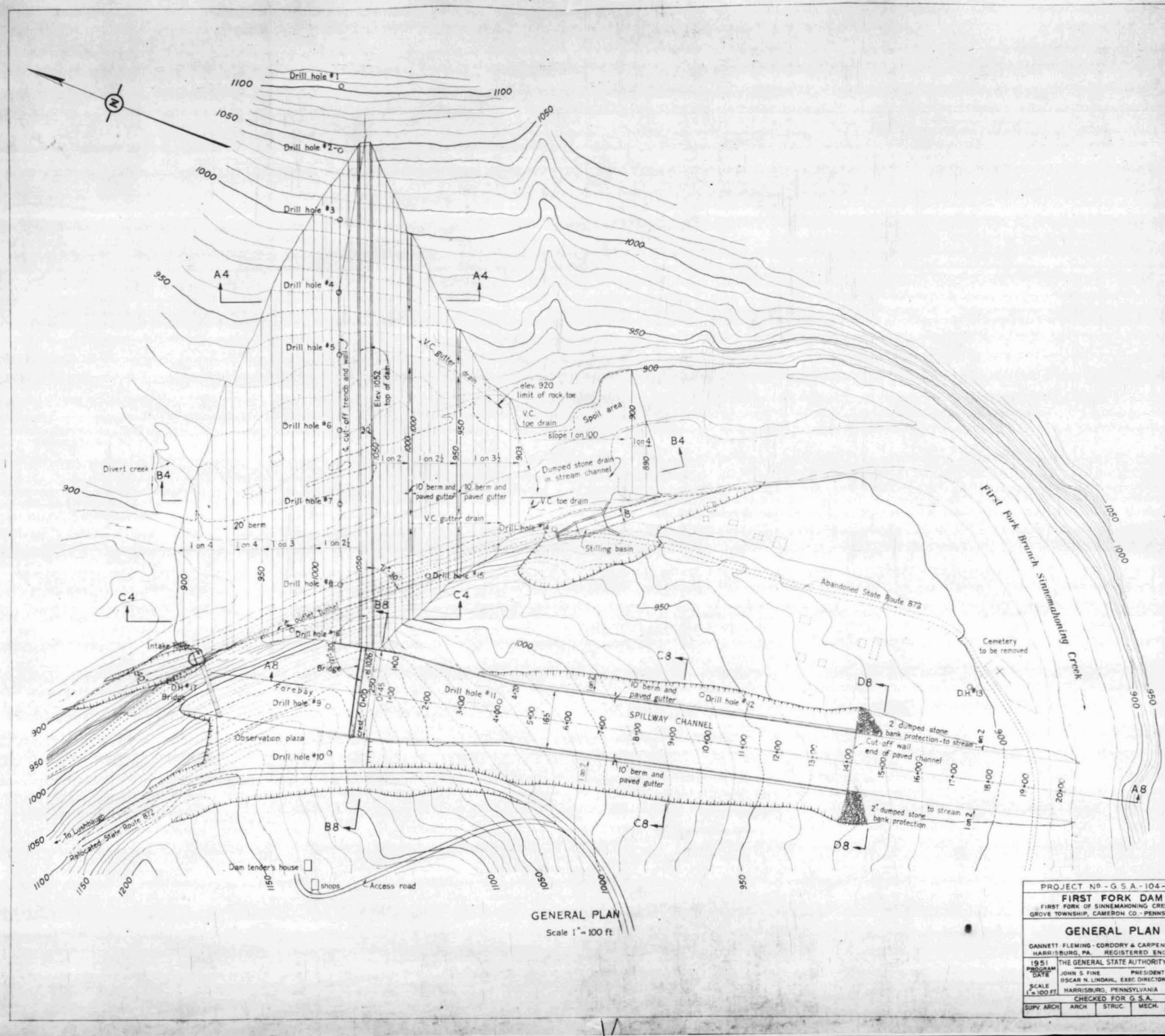
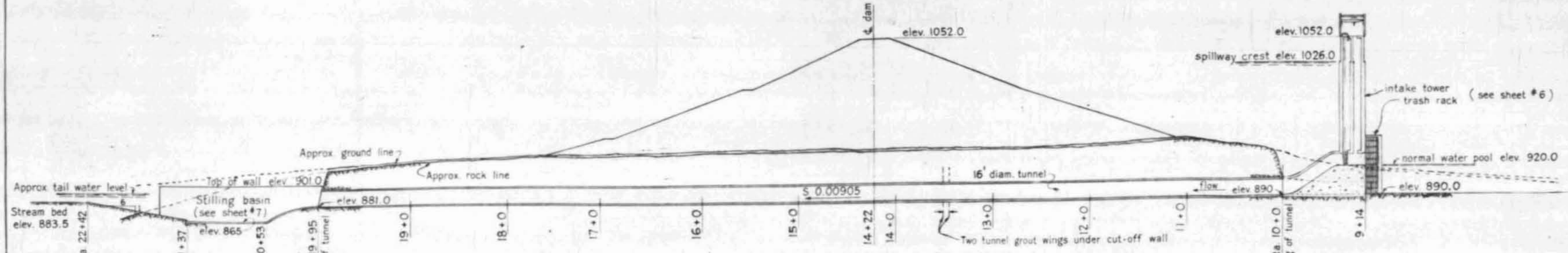
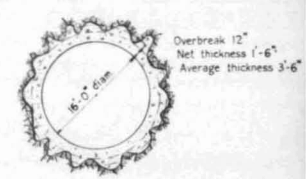

N
Drill hole #1
Drill hole #2
Drill hole #3
Drill hole #4
Drill hole #5
Drill hole #6
Drill hole #7
Drill hole #8
Drill hole #9
Drill hole #10
Drill hole #11
Drill hole #12
Drill hole #14
Drill hole #15
Drill hole #16
D.H. #13
D.H. #17
A4
B4
C4
A8
B8
C8
D8
Elev 1052 top of dam
cut-off trench and wall
V.C. gutter drain
elev. 920 limit of rock toe
V.C. toe drain
Spoil area
slope 1 on 100
Dumped stone drain in stream channel
Divert creek
20' berm
1 on 4
1 on 3
1 on 2½
1 on 2
1 on 3½
10' berm and paved gutter
Stilling basin
outlet tunnel
Intake
Bridge
Forebay
Observation plaza
crest
el 1026
SPILLWAY CHANNEL
165'
Abandoned State Route 872
First Fork Branch Sinnemahoning Creek
Cemetery to be removed
2' dumped stone bank protection - to stream
Cut-off wall end of paved channel
To Lushbaugh
Relocated State Route 872
Dam tender's house
shops
Access road
GENERAL PLAN
Scale 1" = 100 ft
PROJECT No - G.S.A.-104-1.0
FIRST FORK DAM
FIRST FORK OF SINNEMAHONING CREEK
GROVE TOWNSHIP, CAMERON CO. - PENNSYLVANIA
GENERAL PLAN
GANNETT · FLEMING · CORDDRY & CARPENTER IN
HARRISBURG, PA. REGISTERED ENGINEERS
1951 PROGRAM DATE
SCALE 1" = 100 FT
THE GENERAL STATE AUTHORITY
JOHN S. FINE PRESIDENT
OSCAR N. LINDAHL, EXEC DIRECTOR
HARRISBURG, PENNSYLVANIA
SHEET 3
CHECKED FOR G.S.A.
SUPV. ARCH. ARCH. STRUC. MECH. ELE

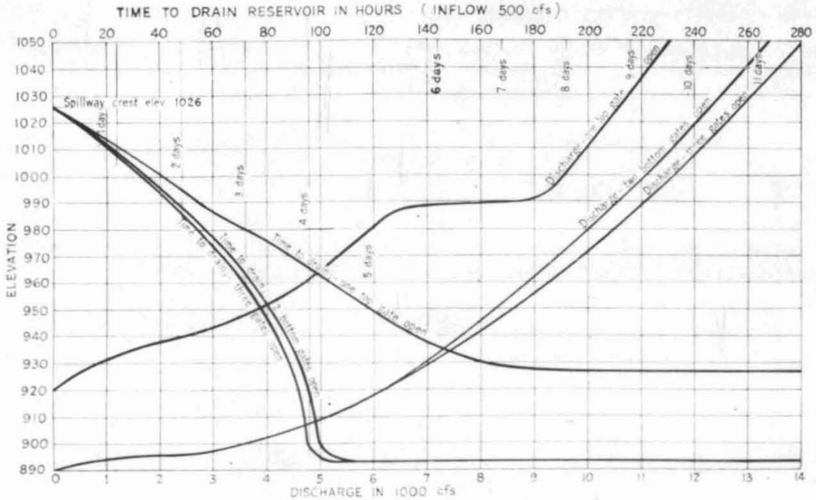
FIGURE 1



SECTION THROUGH ℄ OF TUNNEL
Scale 1"=50'



TYPICAL TUNNEL SECTION
Scale 1/8"=1'0"



DISCHARGE THROUGH INTAKE GATES
AND
TIME TO DRAIN RESERVOIR

FIGURE 2

PROJECT No. - G.S.A. - 104 - 1.0 d

FIRST FORK DAM
FIRST FORK OF SINNEMAHONING CREEK
GROVE TOWNSHIP, CAMERON CO. - PENNSYLVANIA

TUNNEL SECTION AND DISCHARGE CURVE

GANNETT - FLEMING - CORDDRY & CARPENTER INC.
HARRISBURG, PA. REGISTERED ENGINEERS

1951 PROGRAM DATE	THE GENERAL STATE AUTHORITY	SHEET NO.
SCALE AS SHOWN	JOHN S. FINE PRESIDENT OSCAR N. LINDAHL, EXEC. DIRECTOR HARRISBURG, PENNSYLVANIA	5

CHECKED FOR G.S.A.

SUPV. ARCH.	ARCH.	STRUC.	MECH.	ELEC.

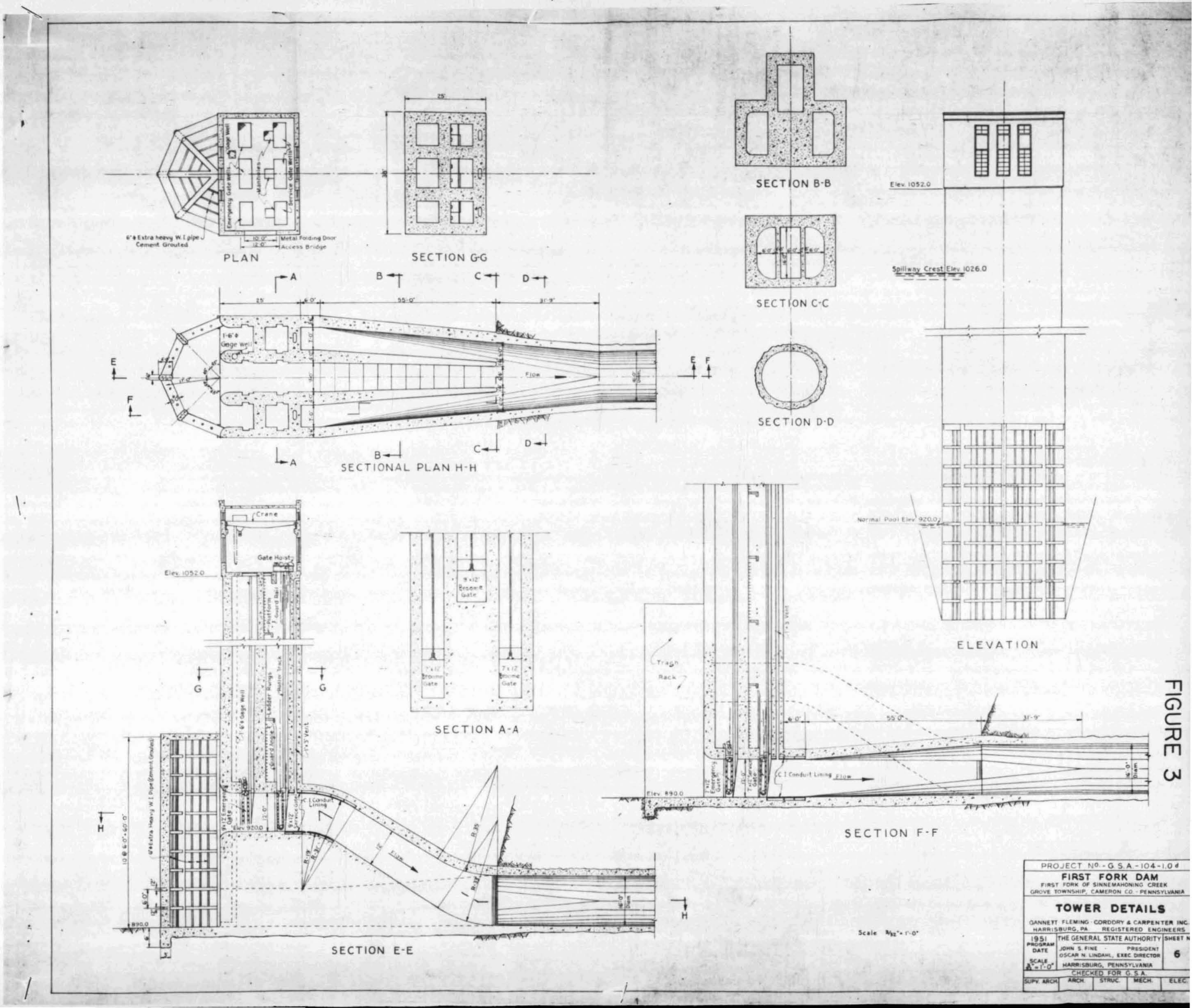

PLAN
6" ø Extra heavy W.I. pipe Cement Grouted
Emergency Gate wells
Manholes
Service Gate wells
Gage Well
Metal Folding Door
Access Bridge
10'-0"
12'-0"
SECTION G-G
25'
SECTION B-B
SECTION C-C
SECTION D-D
Elev. 1052.0
Spillway Crest Elev. 1026.0
Normal Pool Elev. 920.0
ELEVATION
SECTIONAL PLAN H-H
25'
6'-0"
55'-0"
31'-9"
1'-6" ø Gage Well
Flow
Crane
Gate Hoist
Elev. 1052.0
Platform
Guard Rail
Ladder Rungs
Gage Well
Vent
Elev. 920.0
Emergency Gate
Service Gate
C.I. Conduit Lining
6" ø Extra Heavy W.I. Pipe (Cement Grouted)
10 @ 6'-0" = 60'-0"
890.0
Flow
SECTION E-E
9' x 12' Broome Gate
7' x 12' Broome Gate
SECTION A-A
Trash Rack
C.I. Conduit Lining
Flow
Elev. 890.0
6'-0"
55'-0"
31'-9"
16'-0" Diam.
SECTION F-F
Scale 3/32" = 1'-0"
PROJECT No. - G.S.A. - 104 - 1.0 d
FIRST FORK DAM
FIRST FORK OF SINNEMAHONING CREEK
GROVE TOWNSHIP, CAMERON CO. - PENNSYLVANIA
TOWER DETAILS
GANNETT FLEMING - CORDDRY & CARPENTER INC.
HARRISBURG, PA. REGISTERED ENGINEERS
1951 PROGRAM DATE
THE GENERAL STATE AUTHORITY
JOHN S. FINE - PRESIDENT
OSCAR N. LINDAHL, EXEC. DIRECTOR
HARRISBURG, PENNSYLVANIA
SHEET No. 6
CHECKED FOR G.S.A.
SUPV. ARCH. ARCH. STRUC. MECH. ELEC.

FIGURE 3

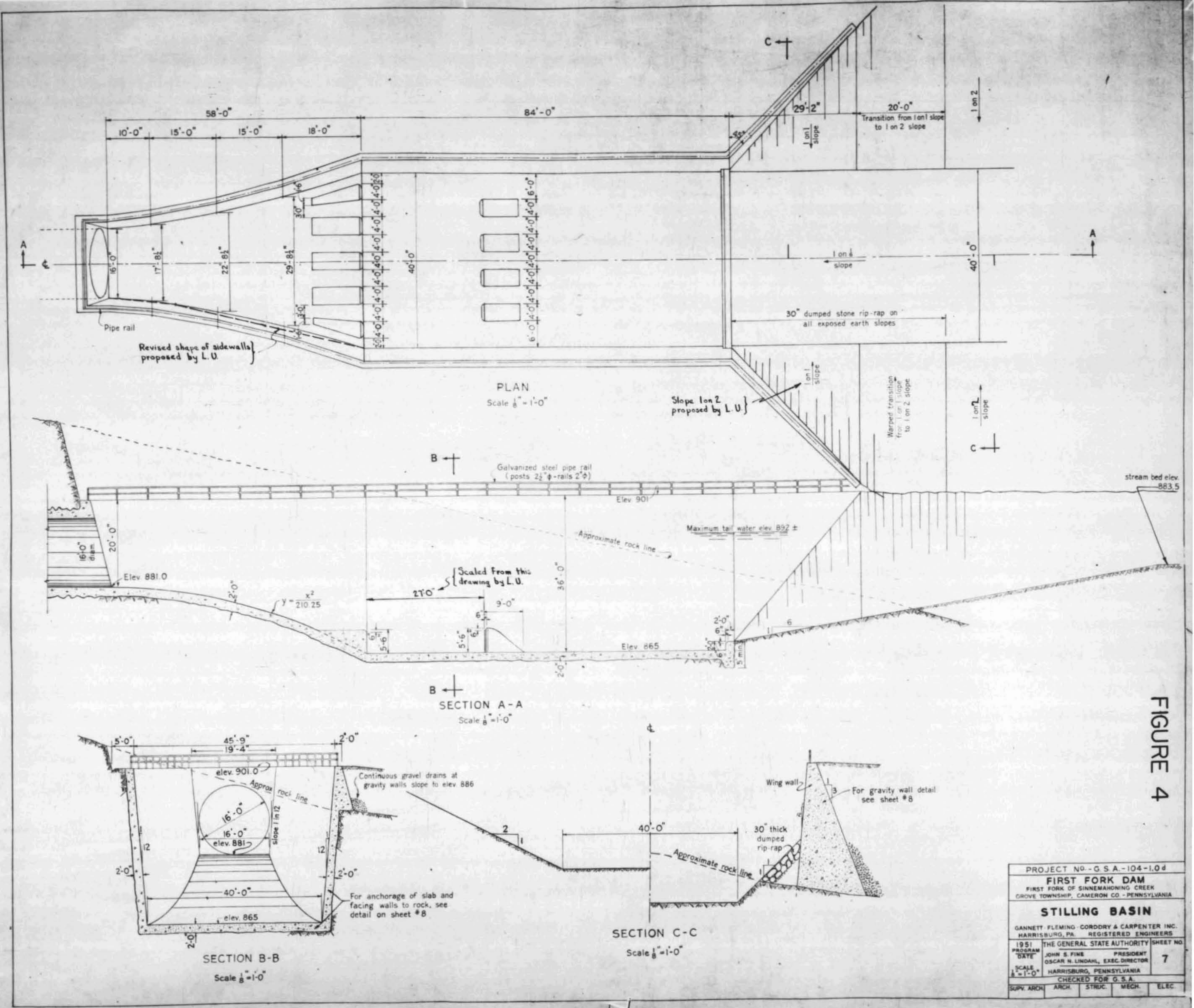

PLAN
Scale 1/8" = 1'-0"
58'-0"
84'-0"
10'-0"
15'-0"
15'-0"
18'-0"
29'-2"
20'-0"
Transition from 1 on 1 slope to 1 on 2 slope
1 on 2
1 on 1 slope
16'-0"
17'-8½"
22'-8½"
29'-8½"
40'-0"
1 on 6 slope
Pipe rail
Revised shape of sidewalls proposed by L.U.
30" dumped stone rip-rap on all exposed earth slopes
Slope 1 on 2 proposed by L.U.
Warped transition from 1 on 1 slope to 1 on 2 slope
SECTION A-A
Scale 1/8" = 1'-0"
Galvanized steel pipe rail (posts 2½" φ - rails 2" φ)
Elev 901
stream bed elev. 883.5
Maximum tail water elev. 892 ±
Approximate rock line
16'-0" diam
20'-0"
Elev 881.0
$y = \frac{x^2}{210.25}$
Scaled from this drawing by L.U.
27'-0"
9'-0"
36'-0"
Elev 865
SECTION B-B
Scale 1/8" = 1'-0"
45'-9"
19'-4"
elev. 901.0
Approx rock line
Continuous gravel drains at gravity walls slope to elev. 886
16'-0"
elev. 881
slope 1 in 12
40'-0"
elev. 865
For anchorage of slab and facing walls to rock, see detail on sheet #8
SECTION C-C
Scale 1/8" = 1'-0"
40'-0"
Approximate rock line
Wing wall
For gravity wall detail see sheet #8
30" thick dumped rip-rap
PROJECT No. - G.S.A. - 104 - 1.0 d
FIRST FORK DAM
FIRST FORK OF SINNEMAHONING CREEK
GROVE TOWNSHIP, CAMERON CO. - PENNSYLVANIA
STILLING BASIN
GANNETT · FLEMING · CORDDRY & CARPENTER INC.
HARRISBURG, PA. REGISTERED ENGINEERS
1951 PROGRAM DATE
THE GENERAL STATE AUTHORITY
JOHN S. FINE PRESIDENT
OSCAR N. LINDAHL, EXEC. DIRECTOR
HARRISBURG, PENNSYLVANIA
SHEET NO. 7
SCALE 1/8" = 1'-0"
CHECKED FOR G.S.A.
SUPV. ARCH. ARCH. STRUC. MECH. ELEC.

FIGURE 4

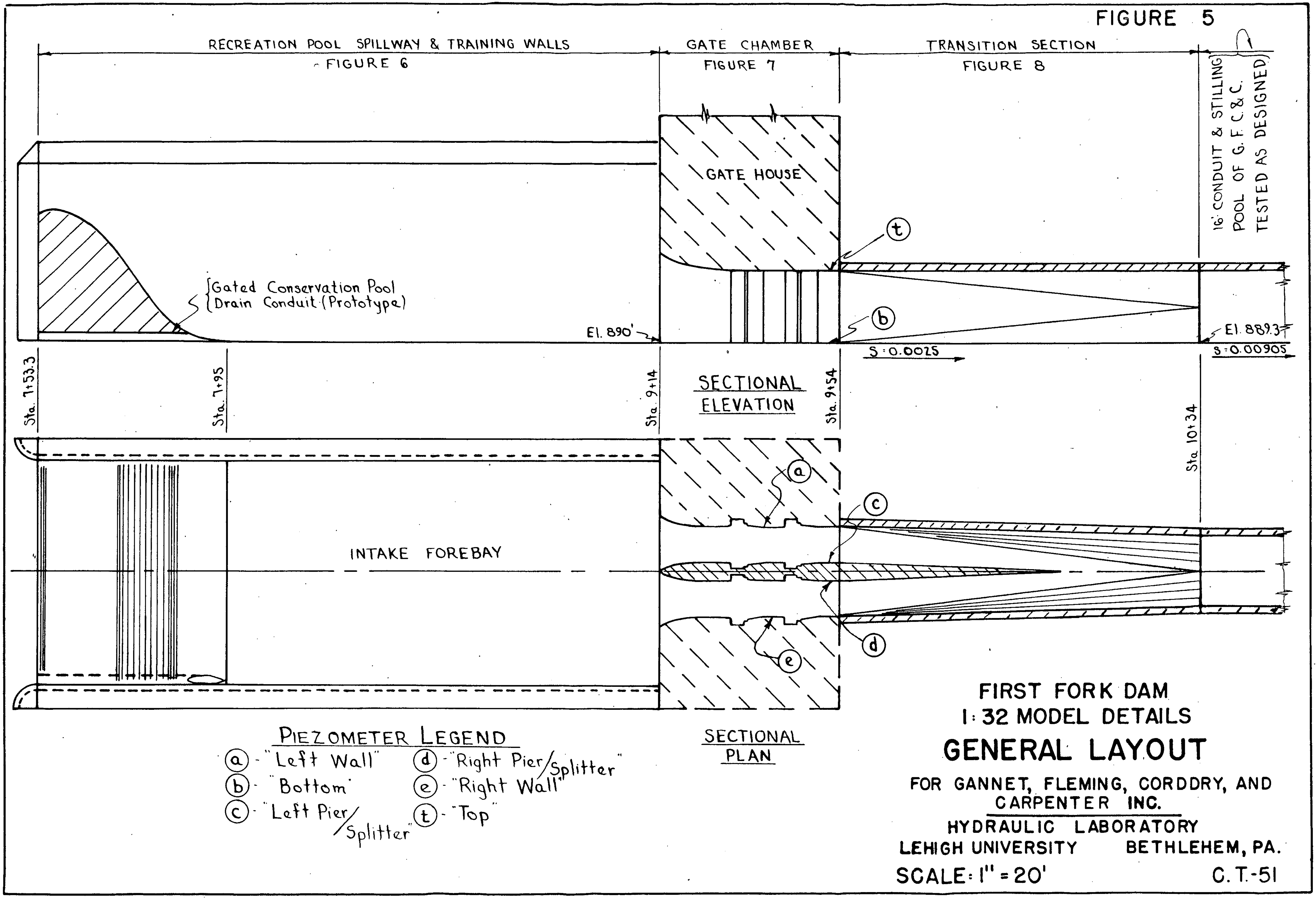
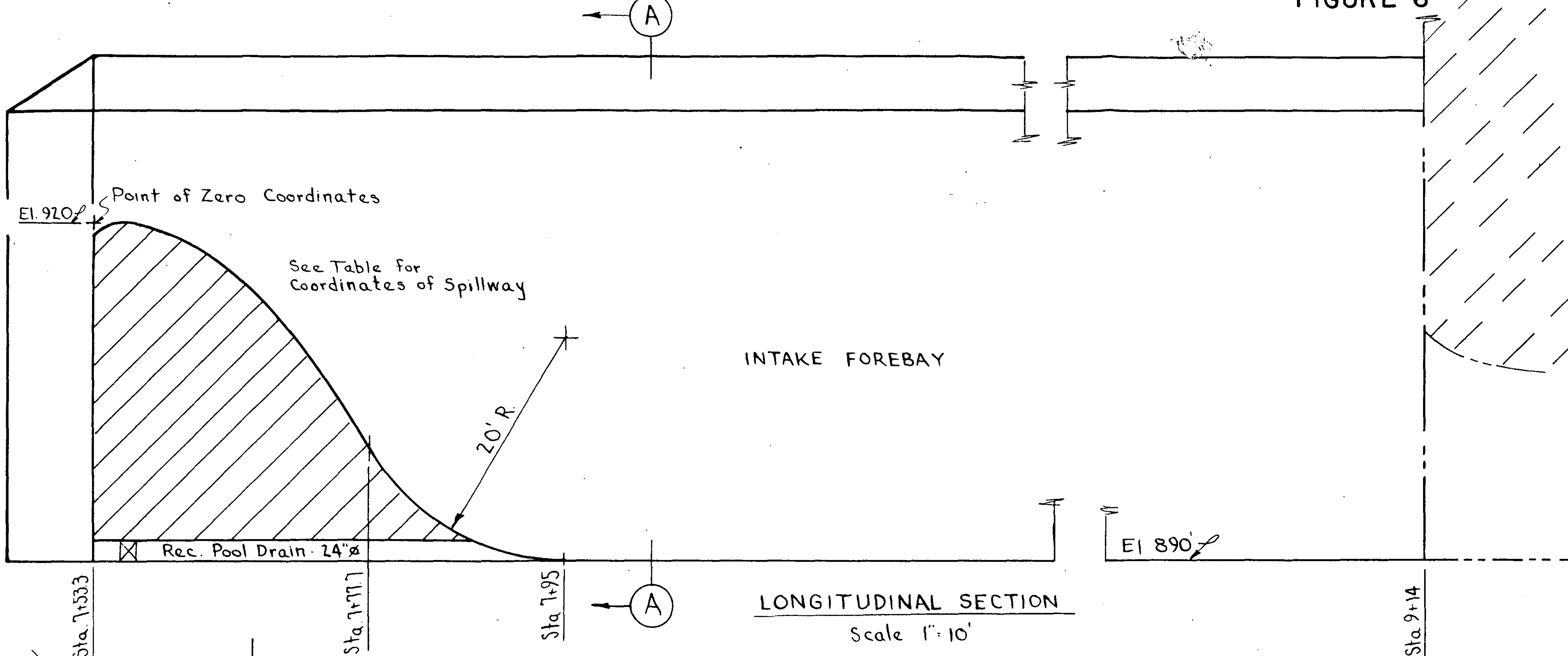
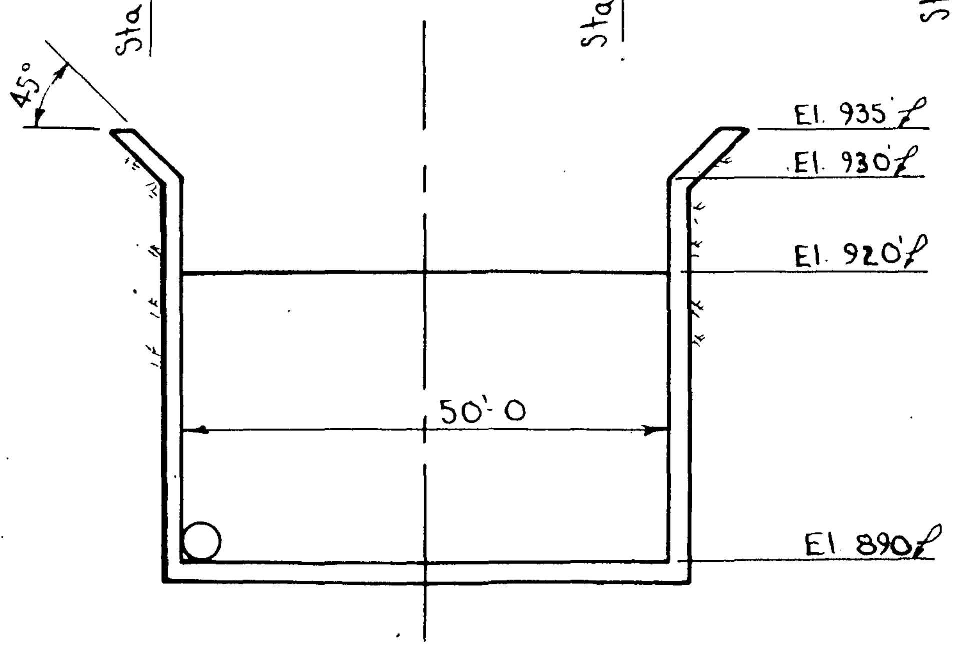


FIGURE 5
RECREATION POOL SPILLWAY & TRAINING WALLS
FIGURE 6
GATE CHAMBER
FIGURE 7
TRANSITION SECTION
FIGURE 8
16' CONDUIT & STILLING POOL OF G. F. C. & C. TESTED AS DESIGNED
GATE HOUSE
Gated Conservation Pool Drain Conduit (Prototype)
El. 890'
El. 889.3
S = 0.0025
S = 0.00905
Sta. 7+53.3
Sta. 7+95
Sta. 9+14
Sta. 9+54
Sta. 10+34
SECTIONAL ELEVATION
INTAKE FOREBAY
SECTIONAL PLAN
PIEZOMETER LEGEND
(a) - "Left Wall"
(b) - "Bottom"
(c) - "Left Pier/Splitter"
(d) - "Right Pier/Splitter"
(e) - "Right Wall"
(t) - "Top"
FIRST FORK DAM
1:32 MODEL DETAILS
GENERAL LAYOUT
FOR GANNET, FLEMING, CORDDRY, AND CARPENTER INC.
HYDRAULIC LABORATORY
LEHIGH UNIVERSITY BETHLEHEM, PA.
SCALE: 1" = 20'
C. T.-51

FIGURE 6



LONGITUDINAL SECTION
Scale 1" = 10'

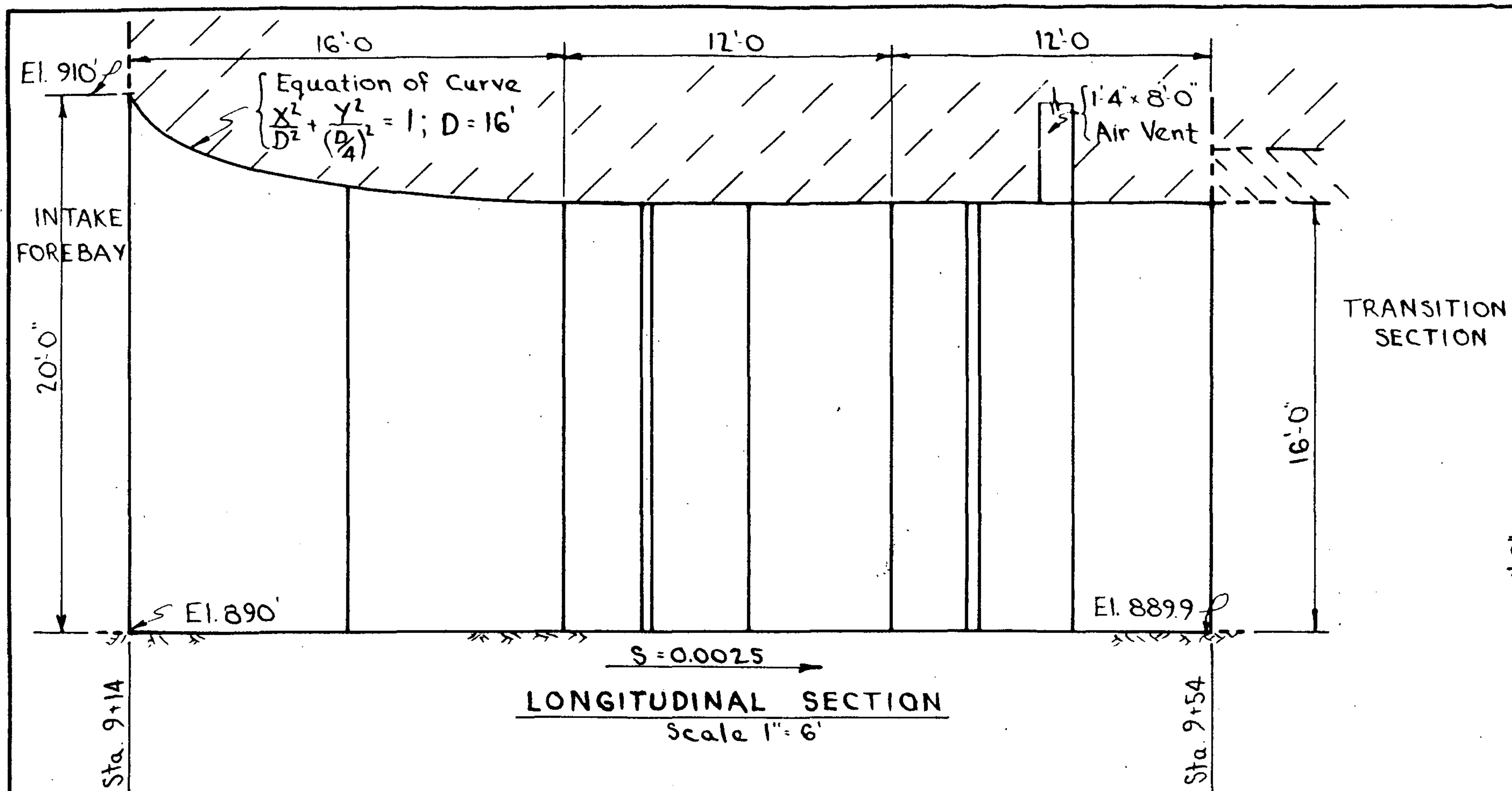


SECTION A-A
Scale 1" = 20'

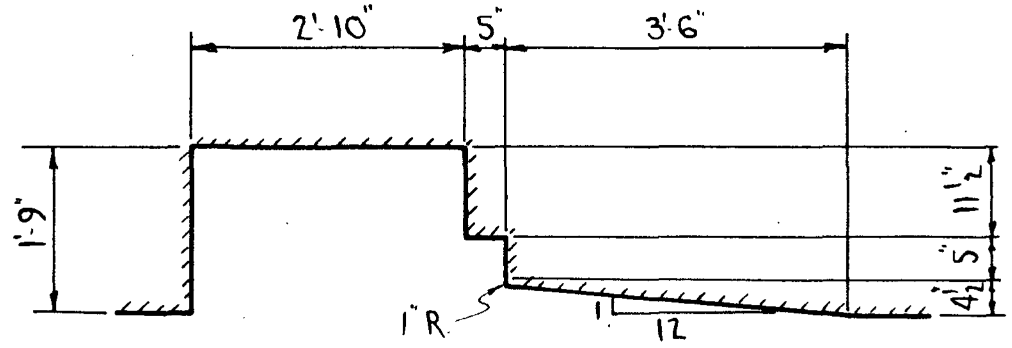
SPILLWAY COORDINATES	
X +	Y -
0'	1.26'
1	0.36
2	0.07
3	0.00
4	0.07
6	0.63
8	1.53
10	2.67
12	4.10
14	5.90
17	9.20
20	13.10
24.40	19.93

FIRST FORK DAM
1:32 MODEL DETAILS
SPILLWAY & INTAKE FOREBAY
FOR GANNET, FLEMING, CORDDRY, & CARPENTER INC.
HYDRAULIC LABORATORY
LEHIGH UNIVERSITY BETHLEHEM, PA.
SCALE: As Shown C.T.-51

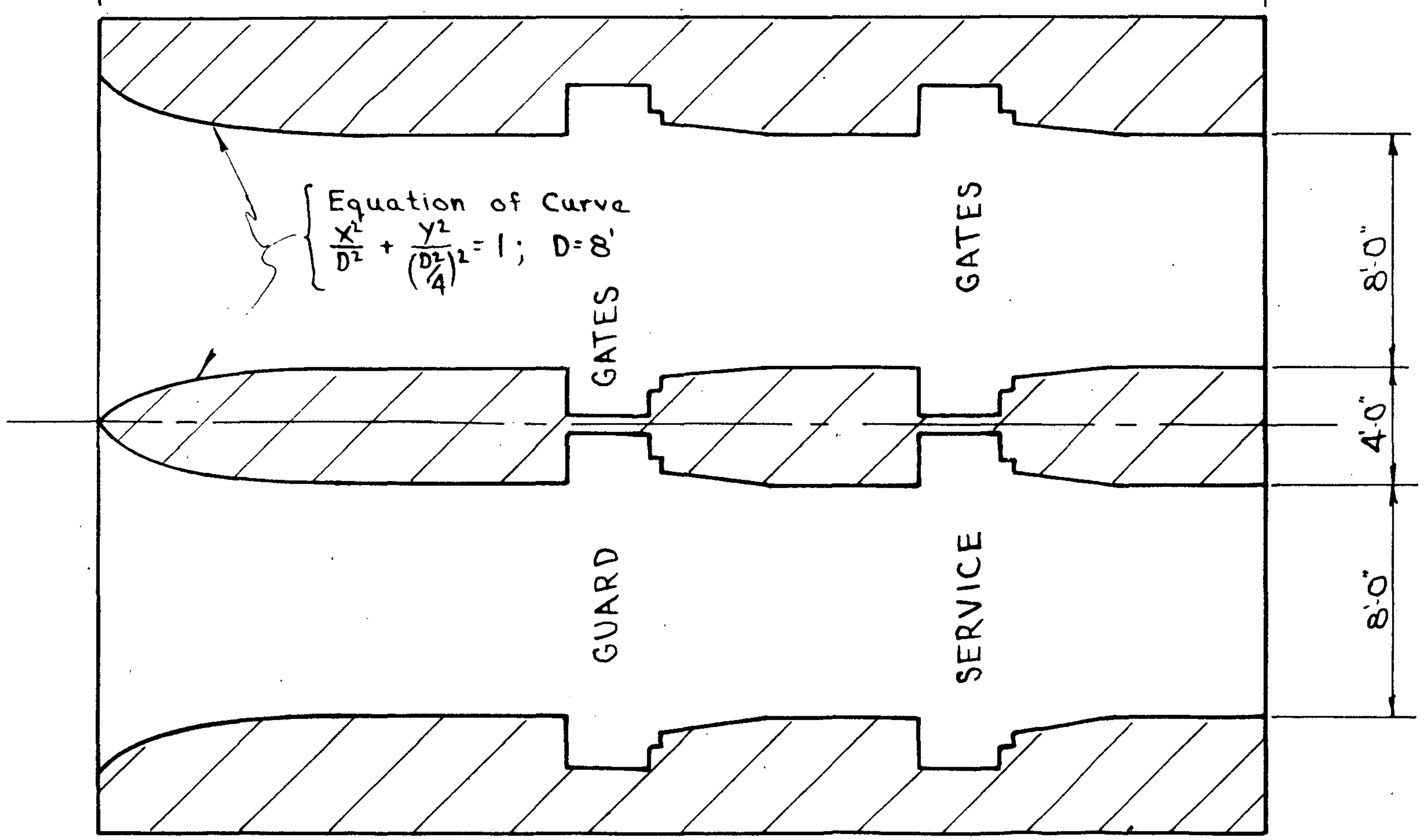
FIGURE 7



LONGITUDINAL SECTION
Scale 1" = 6'



GATE SLOT DIMENSIONS
APPLICABLE TO MODEL
Scale ½" = 1'-0"



SECTIONAL PLAN

FIRST FORK DAM
1:32 MODEL DETAILS

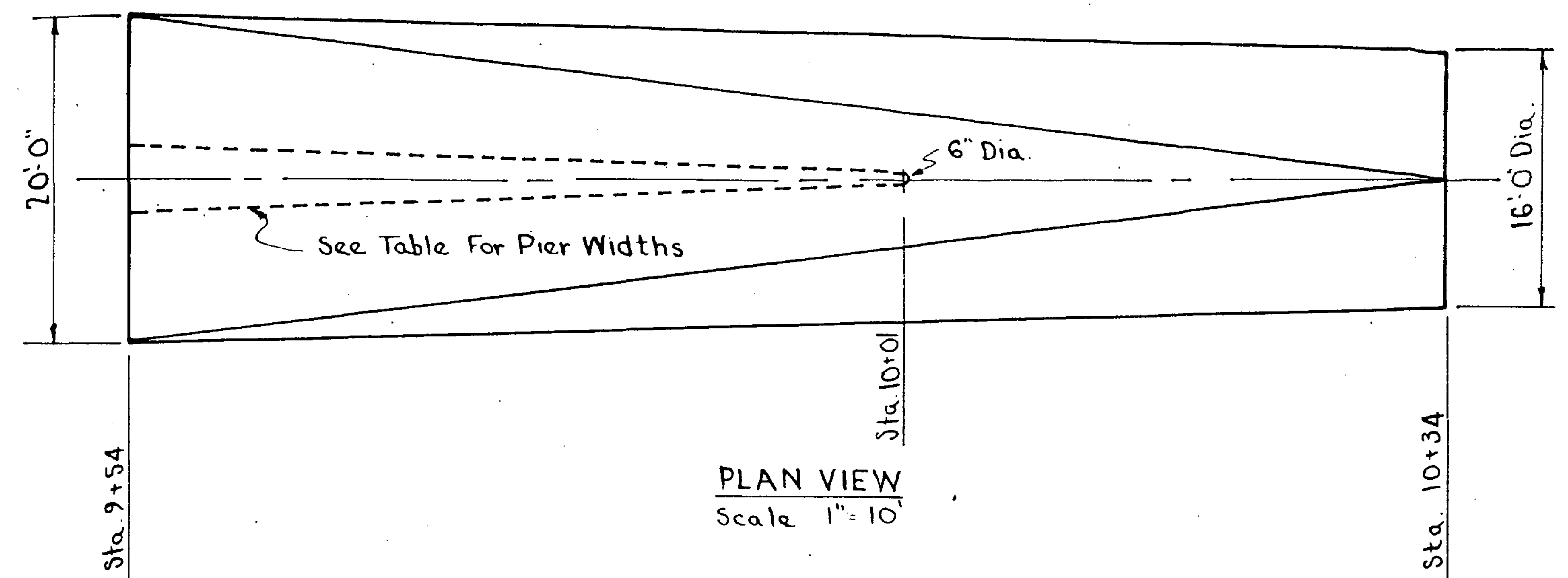
GATE CHAMBER

FOR GANNET, FLEMING, CORDDRY, AND CARPENTER INC.

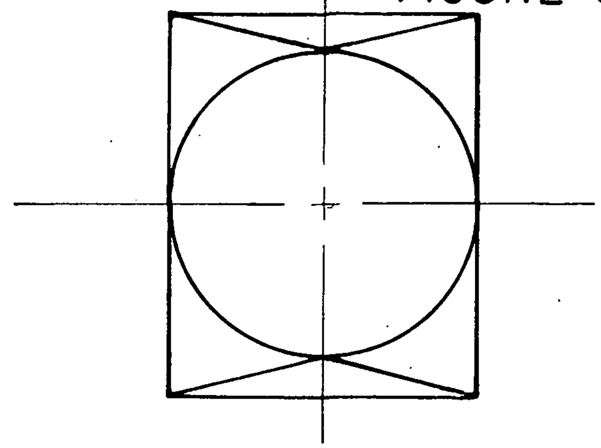
HYDRAULIC LABORATORY
LEHIGH UNIVERSITY BETHLEHEM, PA.

SCALE: AS SHOWN C.T.-51

FIGURE 8

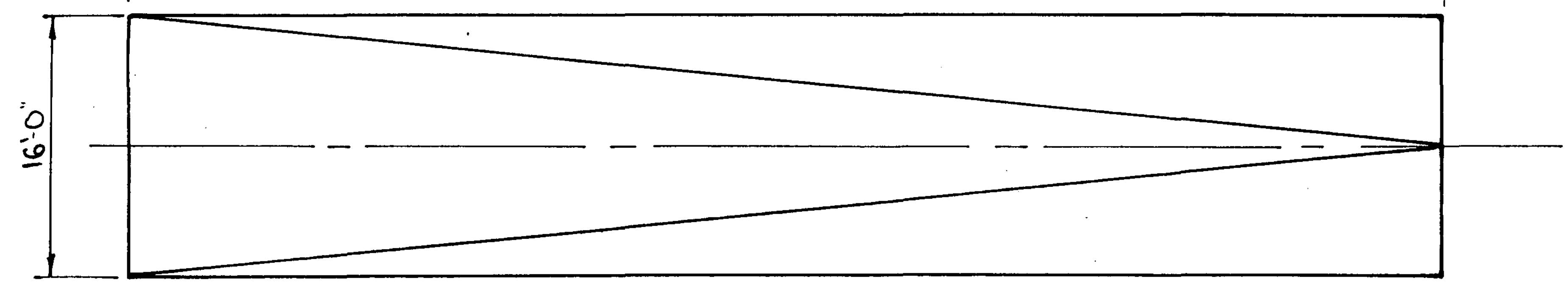


PLAN VIEW
Scale 1" = 10'

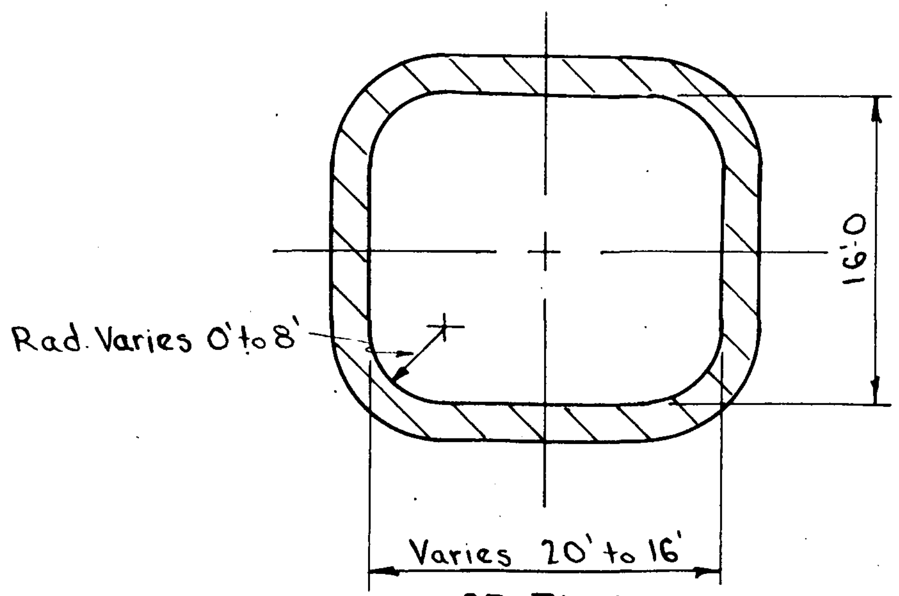


END VIEW

PIER WIDTHS	
STA.	WIDTH
9+54	4.000
9+59	3.749
9+69	3.125
9+79	2.435
9+89	1.592
10+01	0.500

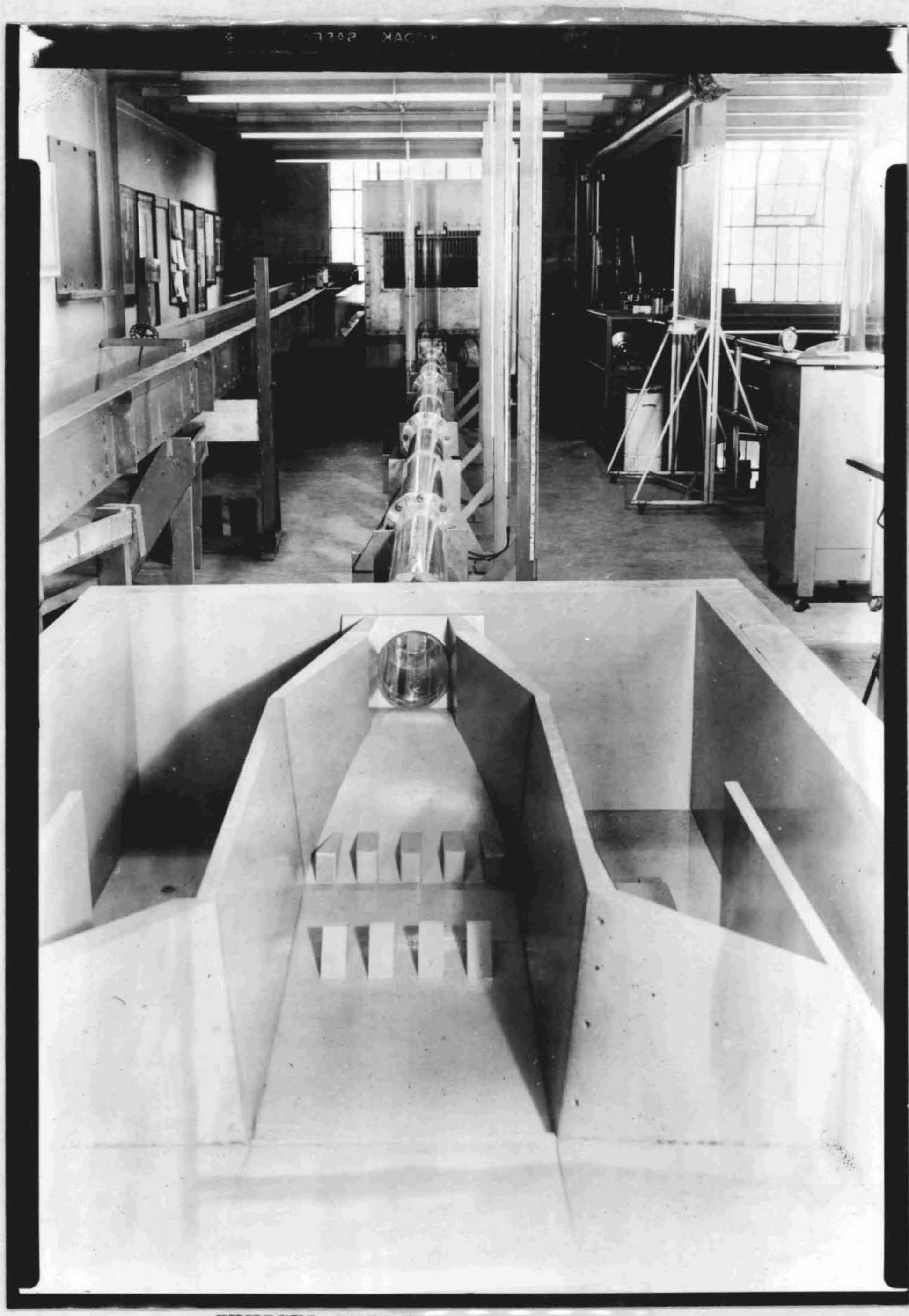


ELEVATION



SECTION

FIRST FORK DAM
1:32 MODEL DETAILS
TRANSITION SECTION
FOR GANNET, FLEMING, CORDDRY, & CARPENTER INC.
HYDRAULIC LABORATORY
LEHIGH UNIVERSITY BETHLEHEM, PA.
SCALE: 1" = 10' C.T.-51



REVISED DESIGN

OVERALL PHOTO

1:32 MODEL

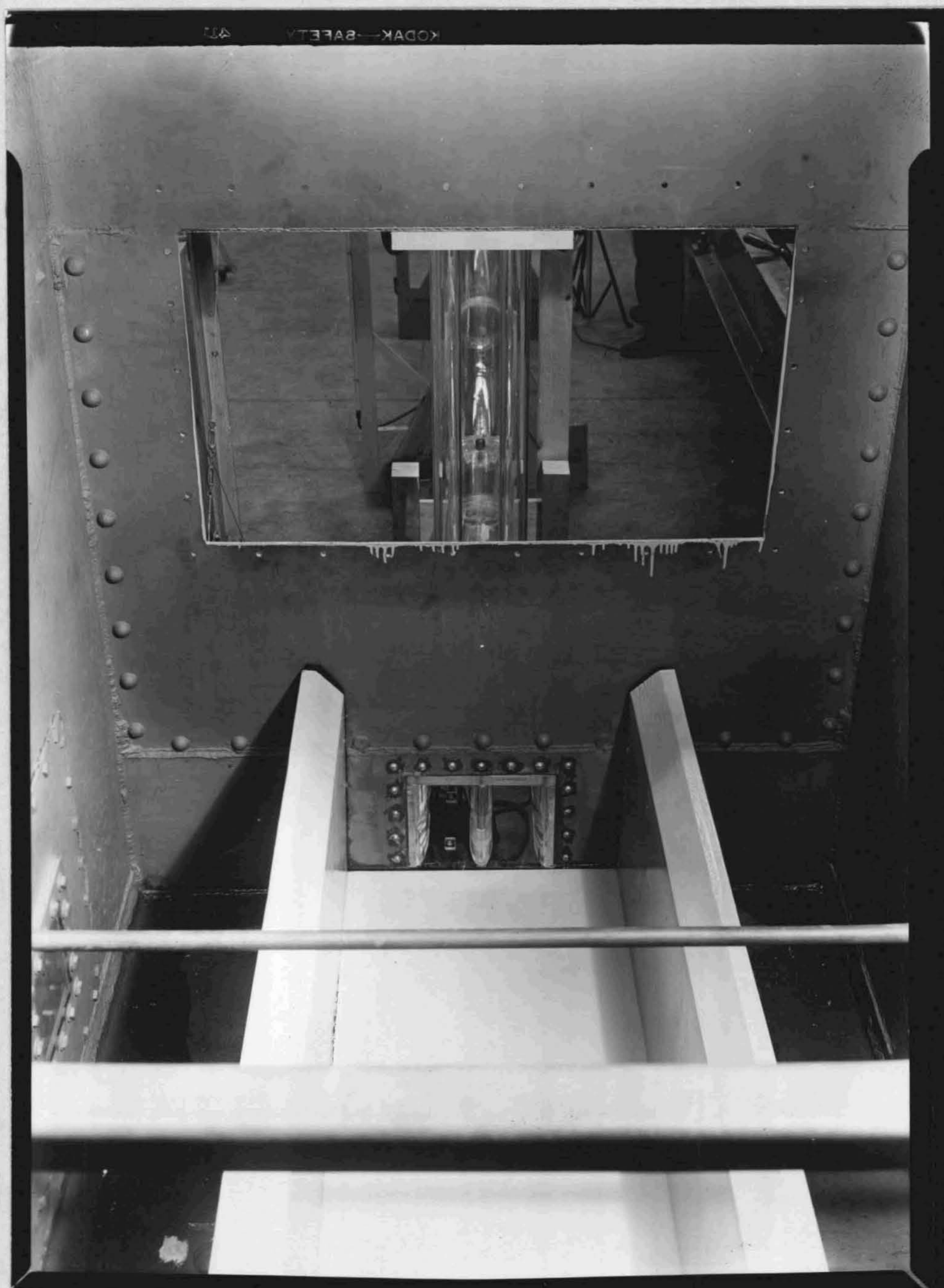
FIGURE 10

REVISED DESIGN

CONDUIT

1:32 MODEL

FIGURE 11



REVISED DESIGN

FOREBAY & INTAKE

1:32 MODEL

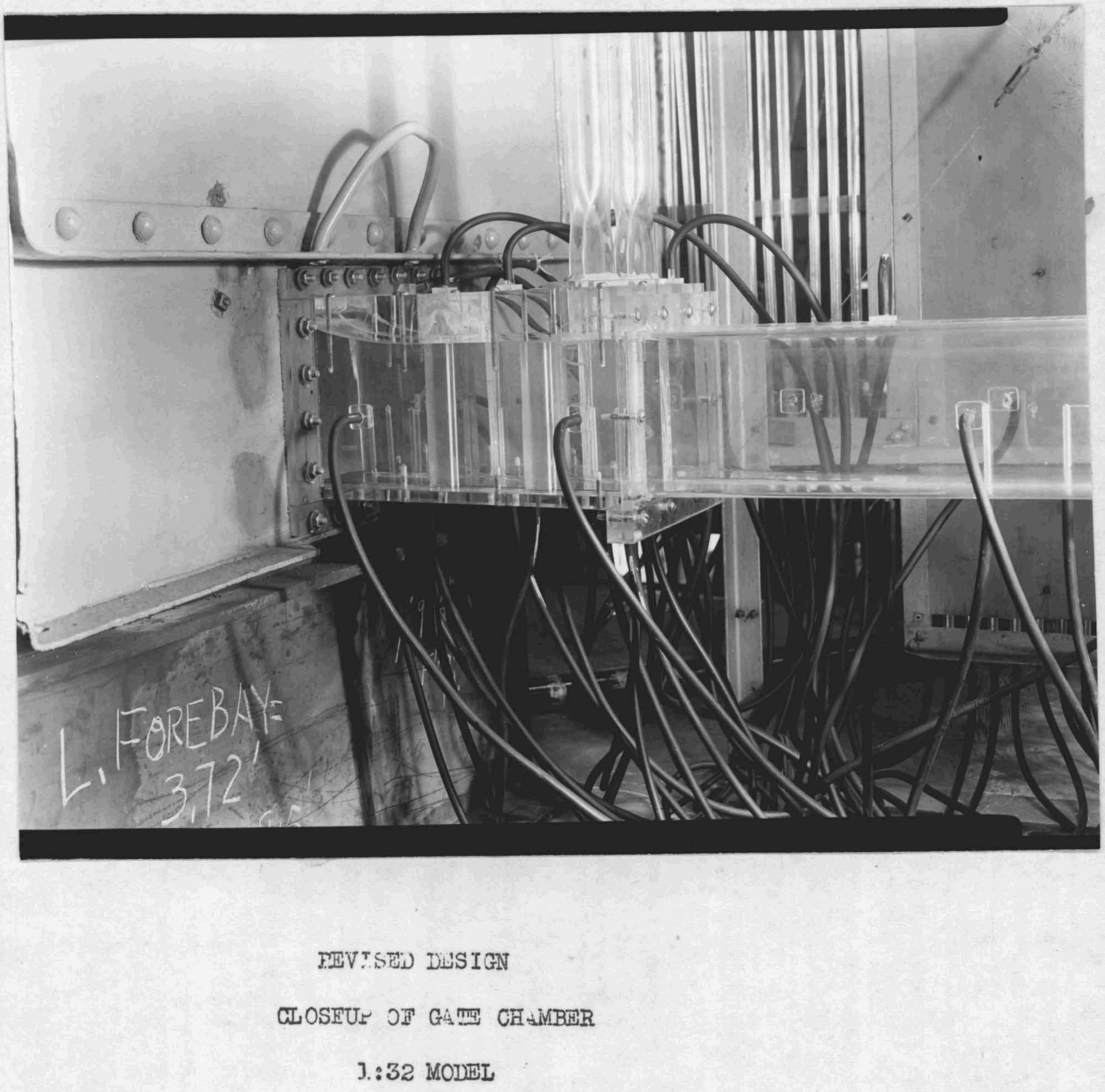
FIGURE 12

REVISED DESIGN

CLOSEUP OF HEADWORKS

1:32 MODEL

FIGURE 13



REVISED DESIGN

CLOSEUP OF GATE CHAMBER

1:32 MODEL

All Data is Given in Terms
of Prototype Values.

FIRST FORK OUTLET STRUCTURE

1:32 MODEL, TEST DATA

TABULATION OF FREE SURFACE WATER LEVELS

RUN NO.	DISCHARGE CFS	FOREBAY LEVEL*	RESERVOIR POOL	REMARKS
1	2,200	905.4	925.2	Gate Chamber and Conduit Aerated.
2	3,000	908.6	926.3	Just past open flow in Gate Chamber--small amount of air from intake.
2A	3,700	909.2	927.2	Small amount of air from intake-flow in conduit slightly unstable.
3	4,800	912.4	928.5	Slight amount of air from intake-just beyond full-flow point.
4	5,300	916.6	929.0	No air drawn from intake.
5	5,800	920.1	929.7	(Air drawn through vents approximately the same as air from intake, under same conditions--for Runs 2 to 3.)
6	6,500	926.2	930.5	
7	8,400	------	947.	
8	10,200	------	971.	
9	11,100	------	987.	
10	12,100	------	1003.	
11	13,000	------	1019.	
12	13,600	------	1030.	
13	14,000	------	1036.	

* FOREBAY--For Runs 1 to 6 the depth indicated obtained for a distance of 60 to 75 feet upstream from the intake in the forebay, which point was roughly the end of the submerged jump.

All Data is Given in Terms of Prototype Values.

FIRST FORK OUTLET STRUCTURE
1:32 MODEL, TEST DATA

24 to 31 July 1952

RUN NUMBER	1	2	3	7	8	9	10	11	12	13
RESERVOIR POOL EL.	925.2	926.3	928.5	947	971	987	1003	1019	1030	1036
FOREBAY LEVEL EL.	905.4	908.6	912.4	---	---	---	---	---	---	---
DISCHARGE, CFS	2,200	3,000	4,800	8,400	10,200	11,100	12,100	13,000	13,600	14,000
PRESSURE HEAD RELATIVE TO GIVEN ELEVATION OF TAP.										
Tap a-1, at Sta. 9+15.3, El.898, Left Wall of Gate Chamber.	5.9	8.0	8.3	33.6	50.9	62.4	74.2	84.8	92.8	96.3
				(In Entrance Curve)						
Tap a-2, at Sta. 9+18.0, El.898, Left Wall of Gate Chamber.	5.9	8.6	10.2	35.8	53.4	64.6	76.2	88.3	96.3	101.4
				(In Entrance Curve)						
Tap a-3, at Sta. 9+22.0, El.898, Left Wall of Gate Chamber.	5.8	8.6	9.6	33.9	49.9	61.4	71.0	82.9	90.6	95.4
				(Point of Tangency, Entrance Curve)						
Tap a-4, at Sta. 9+31.4, El.898, Left Wall of Gate Chamber.	5.8	8.3	9.0	32.0	47.7	58.9	68.5	79.4	86.7	90.9
				(In Center of Roller Guide Slot - Guard Gate)						
Tap a-5, at Sta. 9+33.7, El.898, Left Wall of Gate Chamber.	6.2	9.3	10.9	36.8	55.0	66.9	78.	90.	99.	104.
				(At Beginning of 1 on 12 Gate Slot Taper - Guard Gate)						
Tap a-6, at Sta. 9+38.7, El.898, Left Wall of Gate Chamber.	5.8	8.3	8.6	30.7	45.1	55.4	65.0	75.2	81.9	85.8
				(At End of 1 on 12 Gate Slot Taper - Guard Gate)						
Tap a-7, at Sta. 9+45.7, El.898, Left Wall of Gate Chamber.	6.1	8.9	10.2	34.9	52.8	64.	75.	37.	97.	100.
				(At Beginning of 1 on 12 Gate Slot Taper-Service Gate)						
Tap a-8, at Sta. 9+49.6, El.898, Left Wall of Gate Chamber.	5.6	8.3	8.6	30.4	45.1	54.7	64.0	74.6	81.6	85.4
				(At End of 1 on 12 Gate Slot Taper-Service Gate)						

FIGURE 15

All Data is Given in Terms of Prototype Values.

FIRST FORK OUTLET STRUCTURE
1:32 MODEL, TEST DATA

24 to 31 July 1952

RUN NUMBER	1	2	3	7	8	9	10	11	12	13
RESERVOIR POOL EL.	925.2	926.3	928.5	947	971	987	1003	1019	1030	1036
FOREBAY LEVEL EL.	905.4	908.6	912.4	---	---	---	----	----	----	----
DISCHARGE, CFS	2,200	3,000	4,800	8,400	10,200	11,100	12,100	13,000	13,600	14,000
PRESSURE HEAD RELATIVE TO GIVEN ELEVATION OF TAP.										
Tap a-10, at Sta. 9+65.3, El.893, Left Wall of Transition.	5.4	8.3	8.6	30.4	45.4	55.4	65.0	75.2	82.6	86.7
			(Transition - Across from Splitter Wall)							
Tap a-12, at Sta. 9+88.7, El.898, Left Wall of Transition.	5.4	8.3	8.6	30.1	45.1	54.4	64.0	74.2	81.6	85.4
			(Transition - Across from Splitter Wall)							
Tap a-14, at Sta. 10+18.0, El.898, Left Wall of Transition.	5.3	7.7	7.4	26.6	39.4	48.6	57.0	65.9	72.3	75.5
			(Transition - Beyond Splitter Wall)							
Tap c-1, at Sta. 9+15.3, El.898, Left Side of Splitter Wall.	6.4	9.9	12.5	44.2	64.3	76.5	89.0	103.	112.	118.
			(In Splitter Wall Pier-Left Side - In Entrance Curve)							
Tap c-2, at Sta. 9+18.0, El.898, Left Side of Splitter Wall.	6.2	9.6	11.2	37.8	55.7	67.5	79.4	91.5	100.2	105.6
			(In Entrance Curve)							
Tap c-3, at Sta. 9+22.0, El.898, Left Side of Splitter Wall.	5.9	8.6	9.9	33.9	51.2	62.4	73.9	85.4	93.1	97.9
			(Point of Tangency - Entrance Curve)							
Tap c-5, at Sta. 9+33.7, El.898, Left Side of Splitter Wall.	5.9	8.6	9.9	35.8	56.6	67.5	80.	92.	101.	106.
			(At Beginning of 1 on 12 Gate Slot Taper -Guard Gate)							
Tap c-6, at Sta. 9+36.7, El.898, Left Side of Splitter Wall.	5.8	8.3	8.6	30.4	44.8	55.0	65.3	75.2	81.9	86.4
			(At End of 1 on 12 Gate Slot Taper-Guard Gate)							

FIGURE 16

All Data is Given in Terms of Prototype Values.

FIRST FORK OUTLET STRUCTURE
1:32 MODEL, TEST DATA

24 to 31 July 1952

RUN NUMBER	1	2	3	7	8	9	10	11	12	13
RESERVOIR POOL EL.	925.2	926.3	928.5	947	971	987	1003	1019	1030	1036
FOREBAY LEVEL EL.	905.4	908.6	912.4	---	---	---	----	----	------	------
DISCHARGE, CFS	2,200	3,000	4,800	8,400	10,200	11,100	12,100	13,000	13,600	14,000
PRESSURE HEAD RELATIVE TO GIVEN ELEVATION OF TAP.										
Tap c-7, at Sta. 9+45.7, El.898, Left Side of Splitter Wall. (At Beginning of 1 on 12 Gate Slot Taper - Service Gate)	6.1	9.0	9.0	34.9	51.8	63.0	74.6	86.1	95.4	100.2
Tap c-8, at Sta. 9+49.0, El.898, Left Side of Splitter Wall. (At End of 1 on 12 Gate Slot Taper - Service Gate)	5.4	8.0	8.3	29.1	44.8	54.7	64.6	74.9	81.3	85.8
Tap c-12, at Sta. 9+88.7, El.898, Left Side of Splitter. (Left Side of Splitter - In Transition)	4.2	8.0	8.3	29.1	44.5	54.4	64.3	74.6	81.0	85.8
Tap c-13, at Sta. 10+01.5, El.898, Splitter. (Downstream Tip of Splitter)	4.8	7.4	7.0	25.6	41.9	51.2	61.1	70.7	77.1	81.3
Tap d-3, at Sta. 9+22.0, El.898, Rt. Side Splitter Wall. (Point of Tangency, Entrance Curve)	5.6	8.6	9.6	33.9	50.2	61.4	72.6	83.8	91.5	96.0
Tap d-8, at Sta. 9+49.0, El.898, Rt. Side Splitter Wall. (At End of 1 on 12 Gate Slot Taper - Service Gate)	5.4	8.0	8.3	29.8	43.8	53.8	63.4	73.3	80.3	84.5
Tap e-3, at Sta. 9+22.0, El.898, Rt. Wall Gate Chamber. (Point of Tangency-Entrance Curve)	5.8	8.6	9.6	33.6	49.6	60.8	71.4	82.6	90.2	95.0
Tap e-8, at Sta. 9+49.6, El.898, Rt. Wall Gate Chamber. (At End of 1 on 12 Gate Slot Taper- Service Gate)	5.4	8.3	8.3	30.1	44.8	55.0	65.0	74.9	81.9	86.1
Tap e-12, at Sta. 9+88.7, El.898, Rt. Wall Gate Chamber. (Transition-Across from Splitter Wall)	5.4	8.3	8.3	30.1	44.8	55.0	65.0	74.9	81.9	86.1
Tap e-14, at Sta. 10+18.0, El.898, Rt. Wall Transition. (Transition - Beyond Splitter Wall)	6.9	7.7	7.0	26.2	39.0	48.3	57.0	65.9	72.0	75.5

FIGURE 17

All Data is Given in Terms of Prototype Values.

FIRST FORK OUTLET STRUCTURE

1:32 MODEL, TEST DATA

24 to 31 July 1952

RUN NUMBER	1	2	3	7	8	9	10	11	12	13
RESERVOIR POOL EL.	925.2	926.3	928.5	947	971	987	1003	1019	1030	1036
FOREBAY LEVEL EL.	905.4	908.6	912.4	---	---	---	---	---	---	---
DISCHARGE, CFS	2,200	3,000	4,800	8,400	10,200	11,100	12,100	13,000	13,600	14,000
PRESSURE HEAD RELATIVE TO GIVEN ELEVATION OF TAP.										
Tap t-1, at Sta. 9/15.3, El.908.4 Top of Chamber.	--	--	1.1	24.5	40.8	53.0	64.6	77.0	85.3	89.8
				(In Upper Intake Curve - on Centerline of Left Passage)						
Tap t-3, at Sta. 9/22.0, El.907.4 Top of Chamber.	--	--	0.5	21.0	37.0	47.6	57.8	68.4	75.4	80.2
				(In Upper Intake Curve - on Centerline of Left Passage)						
Tap t-4, at Sta. 9/31.4, El.906.5 Top of Chamber.	--	--	0.8	23.8	39.8	50.7	60.6	71.2	78.2	83.0
				(In Upper Intake Curve - on Centerline of Left Passage)						
Tap t-6.5, El.906. Sta. 9/42.0, Top of Chamber.	--	--	1.0	24.0	39.7	50.6	60.5	70.7	78.1	82.9
				(End of Upper Intake Curve - on Centerline of Left Passage)						
Tap t-9, at Sta. 9/52.7, El.906, Top of Chamber.	--	--	2.6	21.4	38.4	49.0	58.6	69.1	75.8	80.3
				(On Centerline of Top of Left Passage - Just Beyond Air Vent)						
Tap t-11, at Sta. 9/77.4, El.906, Top of Chamber.	--	--	0.3	22.1	36.8	47.0	57.0	66.6	73.9	78.1
				(On Centerline of Top of Left Passage - In Transition)						
Tap b-3, at Sta. 9/22.0, El.890. Bottom.	13.9	16.9	18.2	43.8	60.8	73.0	83.8	95.7	103.4	108.0
				(Floor of Left Gate Passage - Centerline)						
Tap b-6, at Sta. 9/36.7, El.890. Bottom.	13.8	16.6	17.6	41.6	57.6	68.8	79.4	90.2	97.9	102.7
				(Floor of Left Gate Passage - Centerline)						
Tap b-8, at Sta. 9/49.0, El.890. Bottom.	13.8	16.6	17.0	40.6	56.0	66.9	77.4	88.0	95.4	100.2
				(Floor of Left Gate Passage - Centerline)						
Tap b-11, at Sta. 9/77.4, El.890, Bottom.	13.4	16.3	16.3	38.4	53.1	63.4	73.3	83.2	90.2	94.7
				(Floor of Left Passage - Centerline - Transition - Splitter)						
Tap b-13, at Sta. 10/01.5, El.890, Bottom.	12.8	15.7	15.4	37.1	51.5	61.4	70.7	81.0	88.0	91.5
				(Floor of Left Passage - At End of Splitter Wall)						

FIGURE 18

All Data is Given in Terms of Prototype Values.

FIRST FORK OUTLET STRUCTURE
1:32 MODEL, TEST DATA

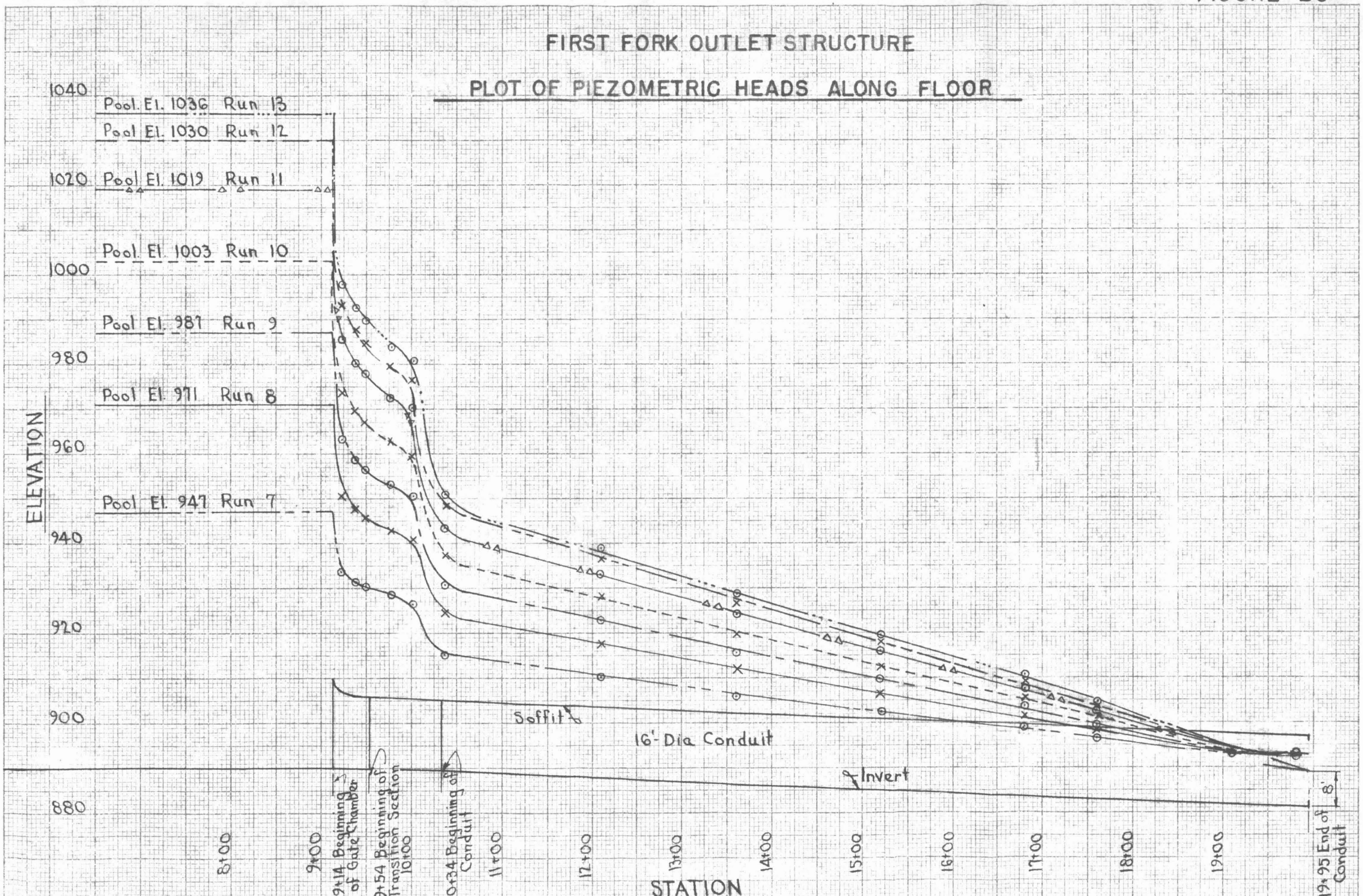
24 to 31 July 1952

RUN NUMBER	1	2	3	7	8	9	10	11	12	13
RESERVOIR POOL EL.	925.2	926.3	928.5	947	971	987	1003	1019	1030	1036
FOREBAY LEVEL EL.	905.4	908.6	912.4	---	---	---	---	---	---	---
DISCHARGE, CFS	2,200	3,000	4,800	8,400	10,200	11,100	12,100	13,000	13,600	14,000
PRESSURE HEAD RELATIVE TO GIVEN ELEVATION OF TAP.										
Tap b-15, at Sta. 10+35.3, El.889.7 Bottom. (Bottom of Conduit - Just Past Transition)	11.5	14.1	11.8	25.9	35.2	41.8	48.0	54.7	59.2	61.8
Tap b-16, at Sta. 12+08, El.888.1, Bottom. (Conduit Invert)	8.8	10.1	11.8	22.4	29.9	35.2	40.3	45.6	49.0	51.5
Tap b-17, at Sta. 13+60, El.886.7, Bottom. (Conduit Invert)	8.3	10.1	11.8	19.8	25.3	29.4	33.6	37.9	40.6	42.2
Tap b-18, at Sta. 15+20, El.885.3, Bottom. (Conduit Invert)	8.0	9.6	12.2	17.6	21.8	25.0	27.7	31.0	33.3	34.7
Tap b-19, at Sta. 16+80, El.883.9, Bottom. (Conduit Invert)	7.5	9.3	12.5	15.4	18.2	20.5	22.1	24.3	25.9	27.2
Tap b-19.5, at Sta. 17+60, El.883.2, Bottom. (Conduit Invert)	7.5	9.1	12.3	13.8	15.7	16.7	18.2	19.8	20.8	21.4
Tap b-20, at Sta. 18+40, El.882.4, Bottom. (Conduit Invert)	7.2	9.0	12.5	11.2	11.4	11.5	11.4	11.2	12.2	12.5
Tap b-21, at Sta. 19+10, El.881.8, Bottom. (Conduit Invert)	7.8	9.6	12.8	11.5	11.4	11.5	11.8	11.5	11.9	12.2
Tap b-22, at Sta. 19+80, El.881.1, Bottom. (Conduit Invert)	8.3	9.4	13.0	11.4	11.2	10.9	11.2	11.5	11.9	11.9

End of Conduit, at Invert, Sta. 19+95, El. 881.0 **

FIGURE 19

FIGURE 20


FIRST FORK OUTLET STRUCTURE
PLOT OF PIEZOMETRIC HEADS ALONG FLOOR
Pool El. 1036 Run 13
Pool El. 1030 Run 12
Pool El. 1019 Run 11
Pool El. 1003 Run 10
Pool El. 987 Run 9
Pool El 971 Run 8
Pool El. 947 Run 7
ELEVATION
1040
1020
1000
980
960
940
920
900
880
Soffit
16' Dia Conduit
Invert
8'
8+00
9+00
9+14 Beginning of Gate Chamber
9+54 Beginning of Transition Section
10+00
10+34 Beginning of Conduit
11+00
12+00
13+00
14+00
15+00
16+00
17+00
18+00
19+00
19+95 End of Conduit
STATION

All Data is Given in
Terms of Prototype Values.

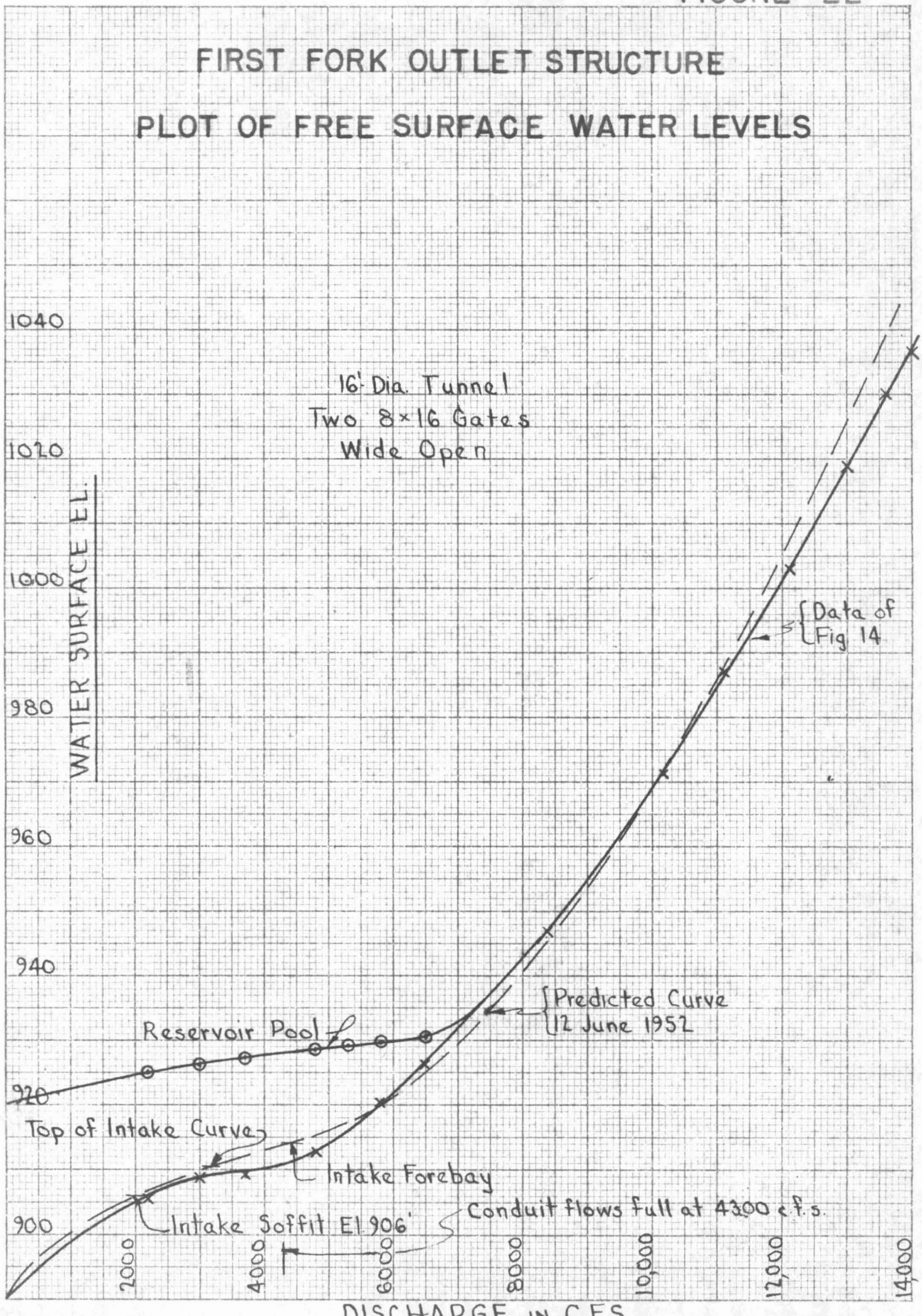
FIRST FORK OUTLET STRUCTURE
1:32 MODEL, TEST DATA

COMPONENTS OF TOTAL HEAD AS INDICATED BY MODEL:

Run	Discharge	Total Head= Pool El.-889.	Conduit Velocity Head	Conduit Head Loss from Station 10/35.3 to 19/95.
7	8,400	58'	27.0'	26.6'
8	10,200	82'	40.0'	35.9'
9	11,100	98'	47.5'	42.5'
10	12,100	114'	56.3'	48.7'
11	13,000	130'	65.0'	55.4'
12	13,600	141'	71.0'	59.9'
13	14,000	147'	75.5'	62.5'

Run	Head Loss from Forebay to Station 10/35.3 in Conduit	Friction Factor, f, Darcy, from Conduit Loss	Equivalent Manning n.
7	4.4'	0.0158	0.0147
8	6.2'	0.0150	0.0143
9	8.0'	0.0149	0.0143
10	9.0'	0.0144	0.0140
11	9.6'	0.0142	0.0139
12	10.1'	0.0141	0.0139
13	9.0'	0.0138	0.0138

FIGURE 22



FIRST FORK OUTLET STRUCTURE
PLOT OF FREE SURFACE WATER LEVELS
16' Dia. Tunnel
Two 8×16 Gates
Wide Open
1040
1020
1000
980
960
940
920
900
WATER SURFACE EL.
Data of Fig. 14
Predicted Curve 12 June 1952
Reservoir Pool
Top of Intake Curve
Intake Forebay
Intake Soffit El. 906'
Conduit flows full at 4300 c.f.s.
2000
4000
6000
8000
10,000
12,000
14,000
DISCHARGE IN C.F.S.

All Data is Given in Terms of Prototype Values.

FIRST FORK OUTLET STRUCTURE
1:32 MODEL, TEST DATA

PRESSURE HEAD IN VENTS COMPARED TO NEARBY TOP TAPS:

Pressure Head Relative to Elevation 906.

Run	t-4	t-6.5	Water Level in Vents	t-9
7	23.8	24.0	24.3	21.4
8	39.8	39.7	40.0	38.4
9	50.7	50.6	51.2	49.0
10	60.6	60.5	62.4	58.6
11	71.2	70.7	73.3	69.1
12	78.2	78.1	80.0	75.8
13	83.0	82.9	84.8	80.3

All Data is Given in Terms
of Prototype Values.

FIRST FORK OUTLET STRUCTURE
1:32 MODEL, TEST DATA

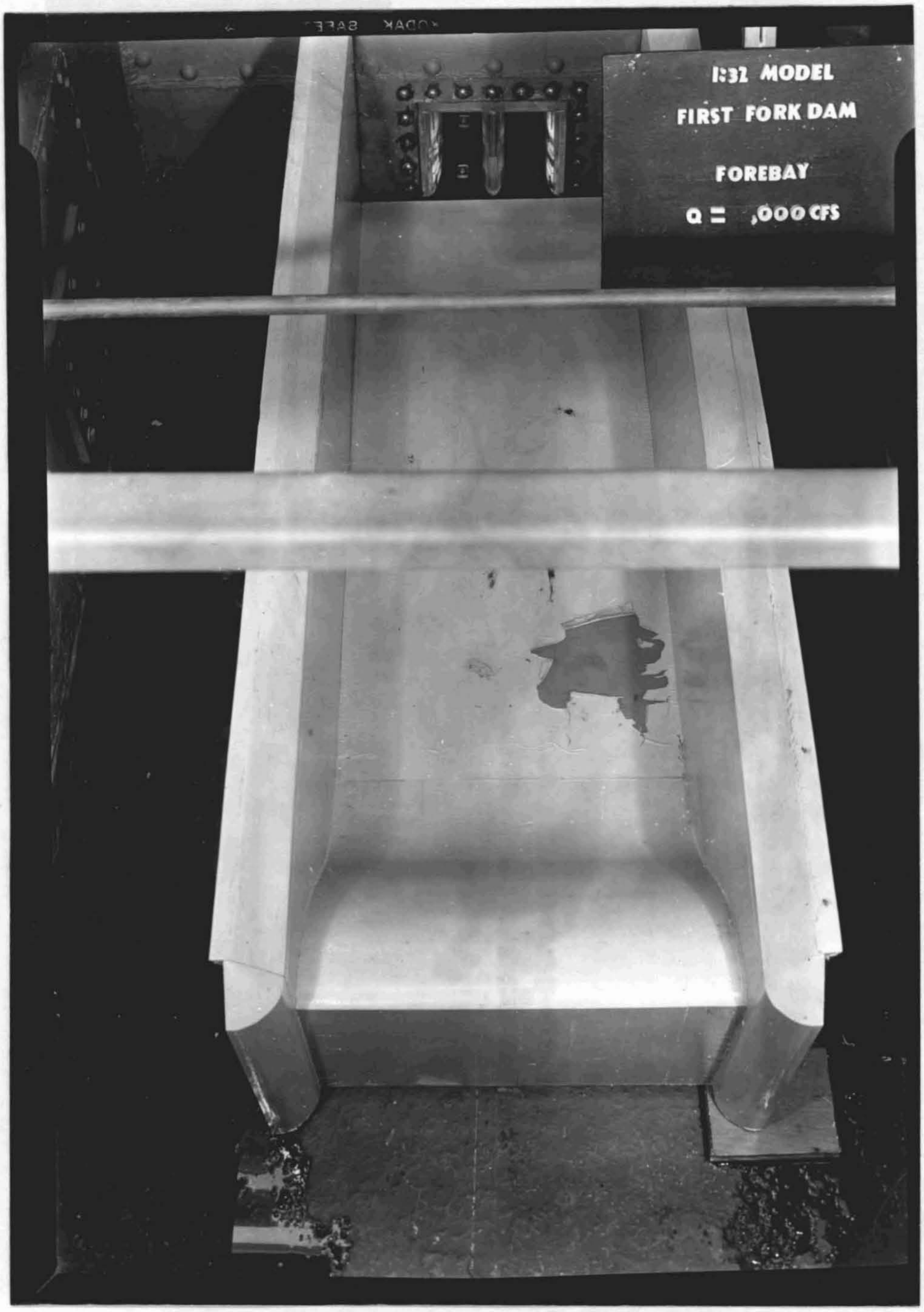
30 July 1952

SPECIAL RUNS WITH RIGHT GATE COMPLETELY CLOSED:

TAP NO.	POSITION (For Details see Runs 1 to 13)	PRESSURE HEAD RELATIVE TO GIVEN ELEVATION OF TAP: RUN NO. R-1 RESERV. POOL 956. 7,100 CFS VENTS OPEN	RUN NO. R-2 RESERV. POOL 980 7,100 CFS VENTS CLOSED	RUN NO. R-3 RESERV. POOL 1031 11,400 CFS VENTS OPEN
a-1	Left Wall	21.8	11.8	49.3
c-1	Left/Pier	20.2	11.2	38 to 42
t-1	Left Top	16.2	8.5	46.6
a-2	Left Wall	21.8	12.8	47.4
c-2	Left/Pier	18.2	9.6	38.1
a-3	Left Wall	13.8	4.2	26.6
b-3	Left Bottom	25.3	16.6	10.9
c-3	Left/Pier	14.1	5.4	29.1
t-3	Left Top	- 1.4	-11.3	5.0
d-3	Right/Pier	57.6	81.6	131.8
e-3	Right Wall	57.6	81.6	131.8
a-4	Left Wall	8.3	0.3	14.4
t-4	Left Top	1.1	- 8.5	10.1
a-5	Left Wall	23.4	10.6	49.6
c-5	Left/Pier	25.3	17.0	56.0
a-6	Left Wall	2.9	- 6.1	1.6
b-6	Left Bottom	19.8	11.2	30.7
c-6	Left/Pier	3.2	- 6.4	1.6
t-6.5	Left Top	0.0	- 8.3	6.7
a-7	Left Wall	17.3	6.7	6.4
c-7	Left/Pier	16.0	7.4	38.7
a-8	Left Wall	2.2	- 6.7	1.6
b-8	Left Bottom	17.0	0.3	16.0
c-8	Left/Pier	2.2	- 7.0	0.0
d-8	Right/Pier	0.0*	- 8.0	- 7.7*
t-9	Left Top	- 2.2	-10.7	1.0
a-10	Left Wall	2.2	- 7.0	2.6
b-11	Left Bottom	10.2	1.3	9.9
t-11	Left Top	- 5.1	-13.1	- 4.8
a-12	Left Wall	2.2	- 7.4	1.0
c-12	Left/Pier	1.6	- 7.7	0.0
e-12	Right Wall	- 1.0*	- 8.3	- 6.4*
b-13	Left Bottom	5.8	- 1.6	0.3
c-13	Tip of Splitter	- 0.6*	- 8.6	- 8.6*
a-14	Left Wall	7.4	- 7.0	2.6
e-14	Right Wall	0.0*	- 9.6	- 7.7*
b-15	Conduit Invert	18.2	11.2	9.9
b-16	Conduit Invert	11.4	17.9	21.1
b-17	Conduit Invert	11.8	16.3	20 to 23
b-18	Conduit Invert	12.6	15.4	25.9
b-19	Conduit Invert	12.8	13.9	22.1
b-20	Conduit Invert	12.3	11.8	15.0

(* Tap not covered by water.)

FIGURE 25

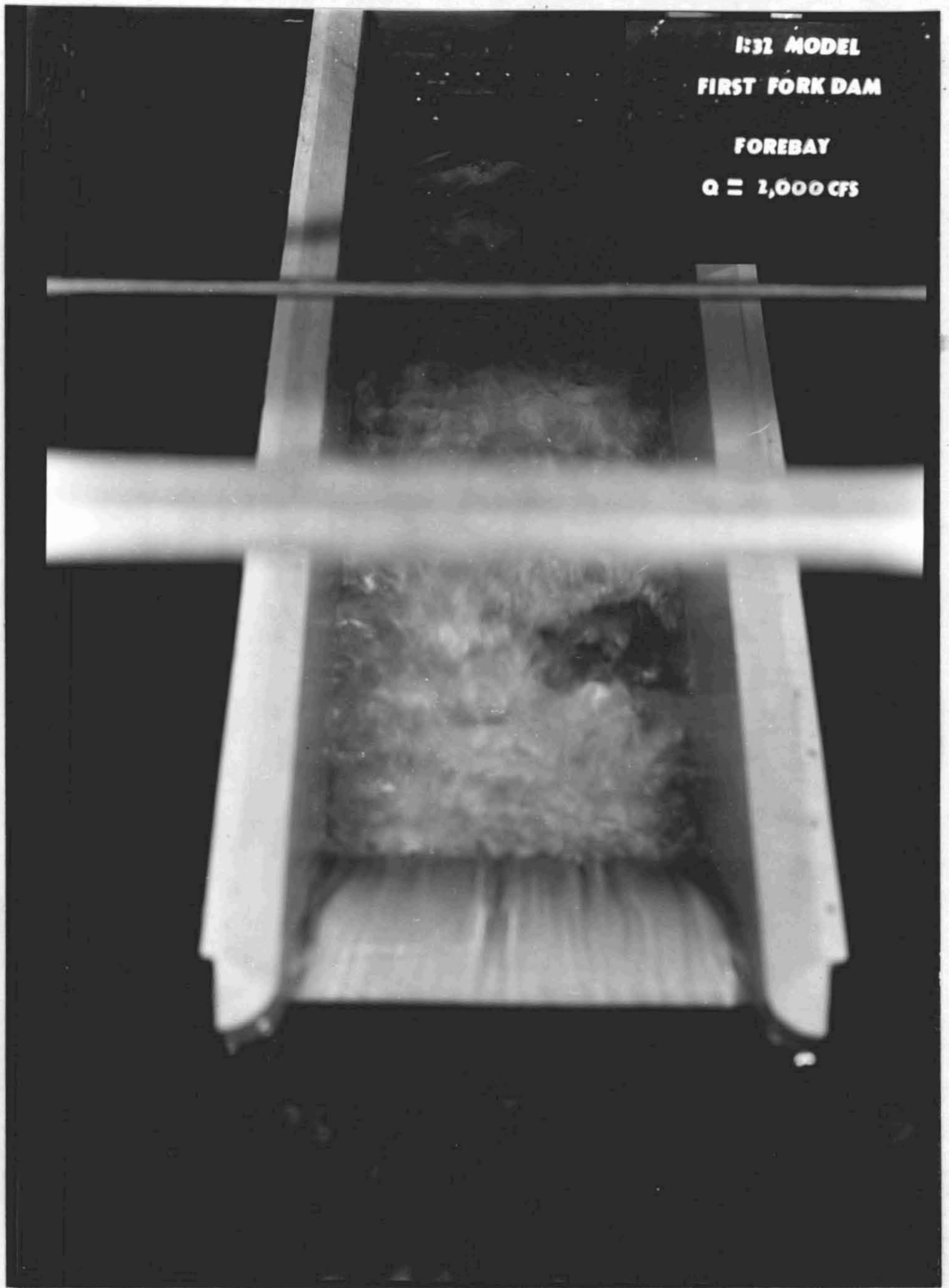


REVISED DESIGN

FOREBAY

1:32 MODEL

FIGURE 26

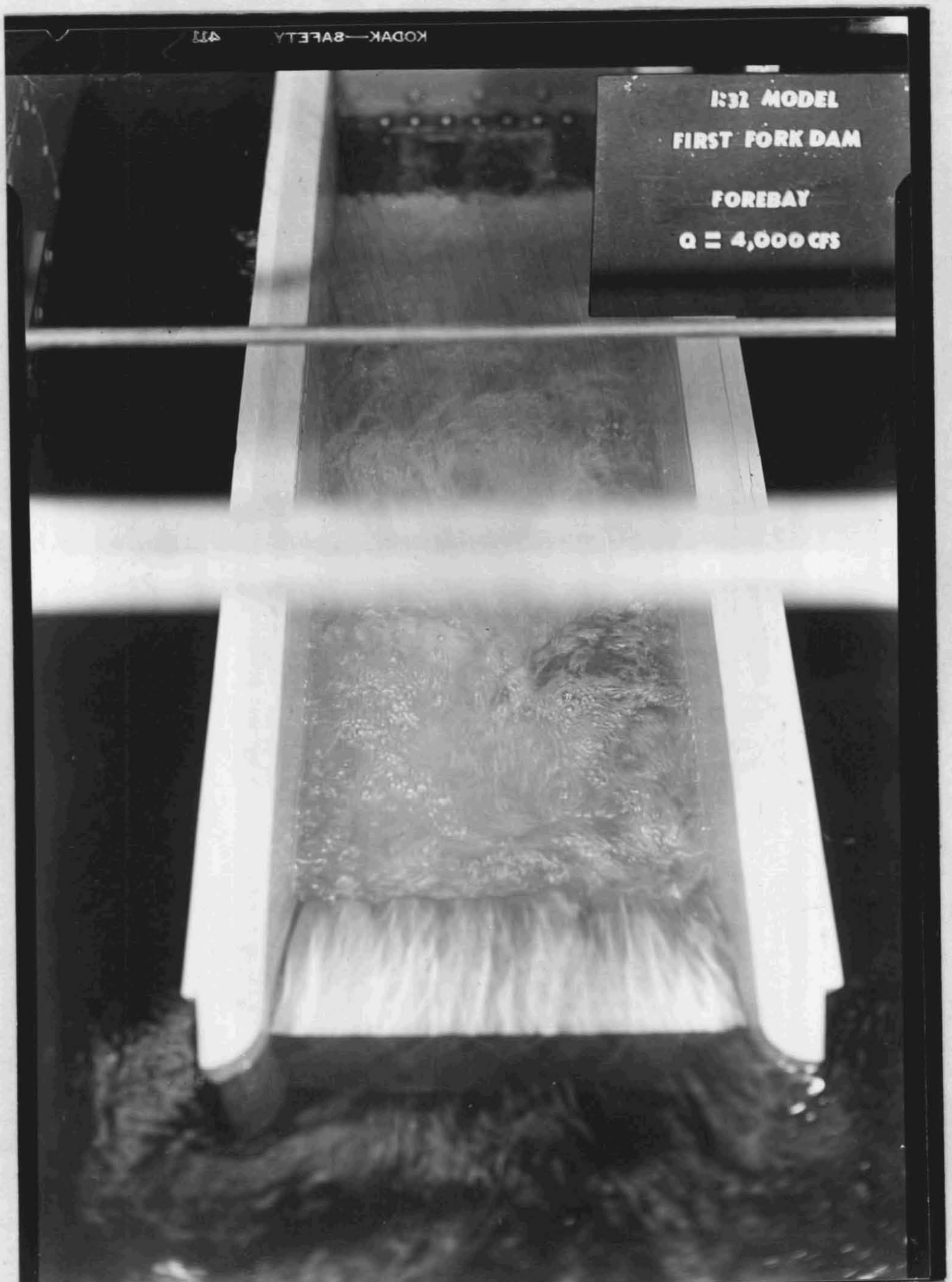


REVISED DESIGN

FOREBAY

2,000 cfs

1:32 MODEL



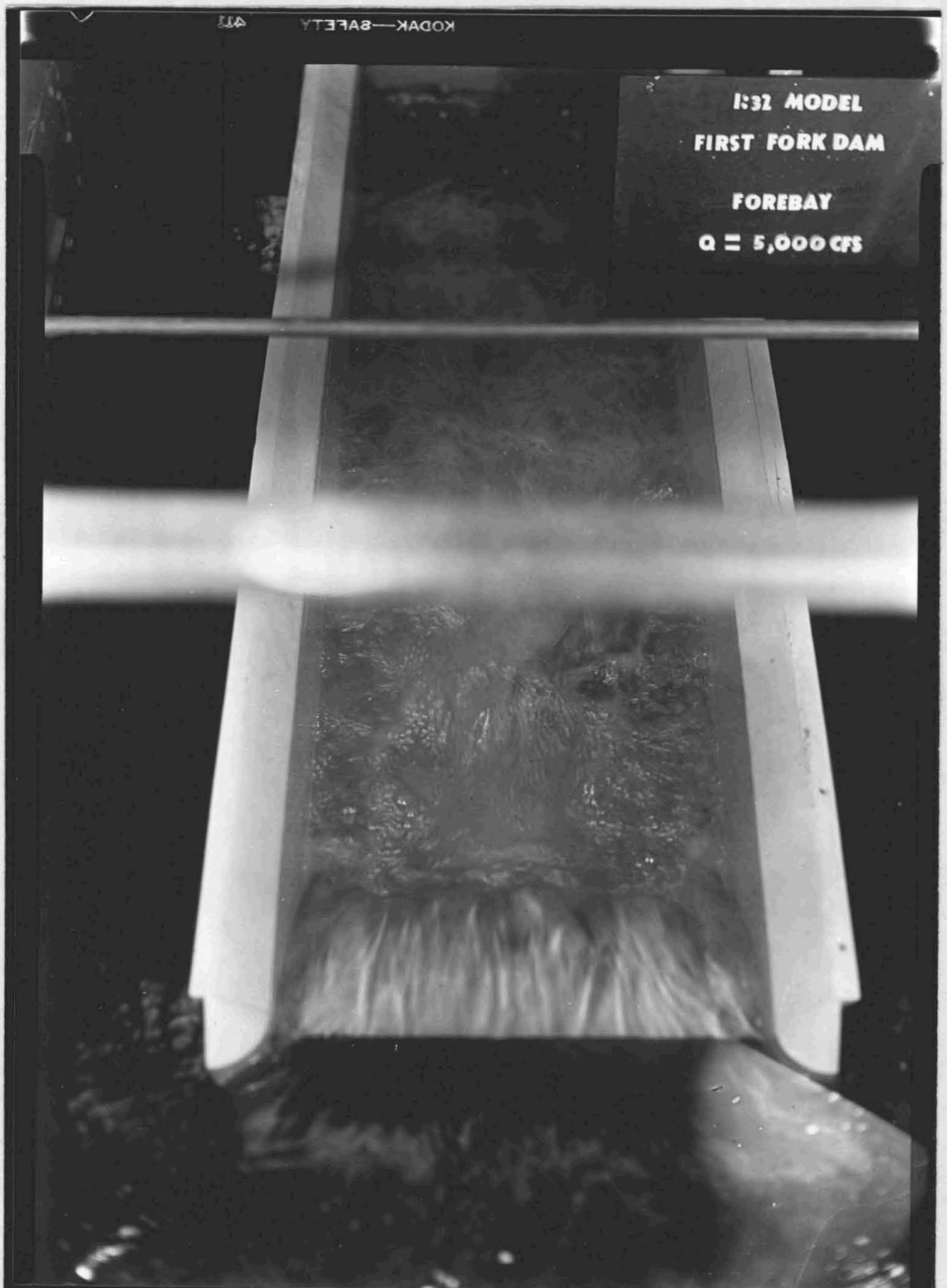
REVISED DESIGN

FOREBAY

4,000 cfs

1:32 MODEL

FIGURE 28

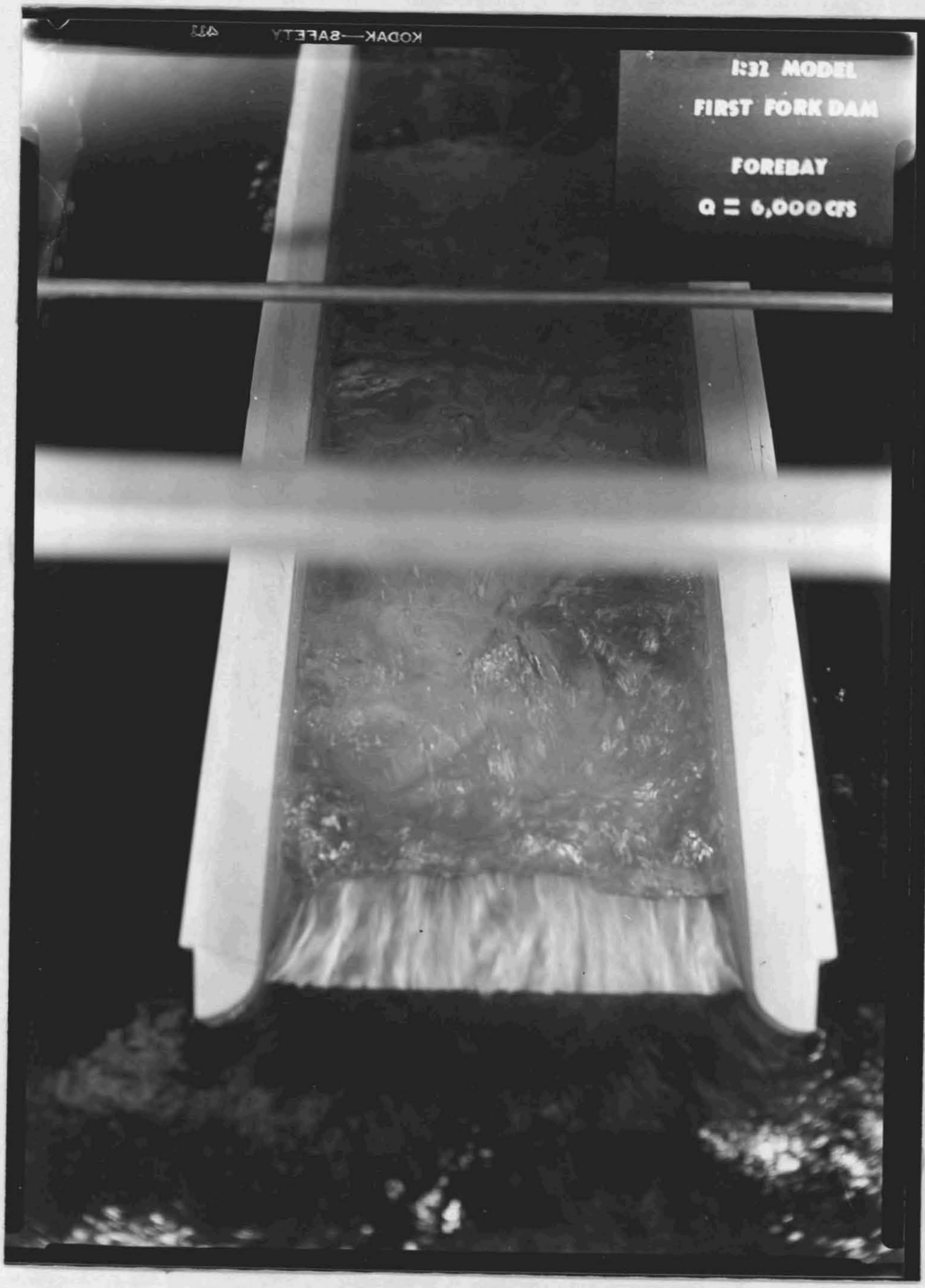


REVISED DESIGN

FOREBAY

5,000 cfs

1:32 MODEL

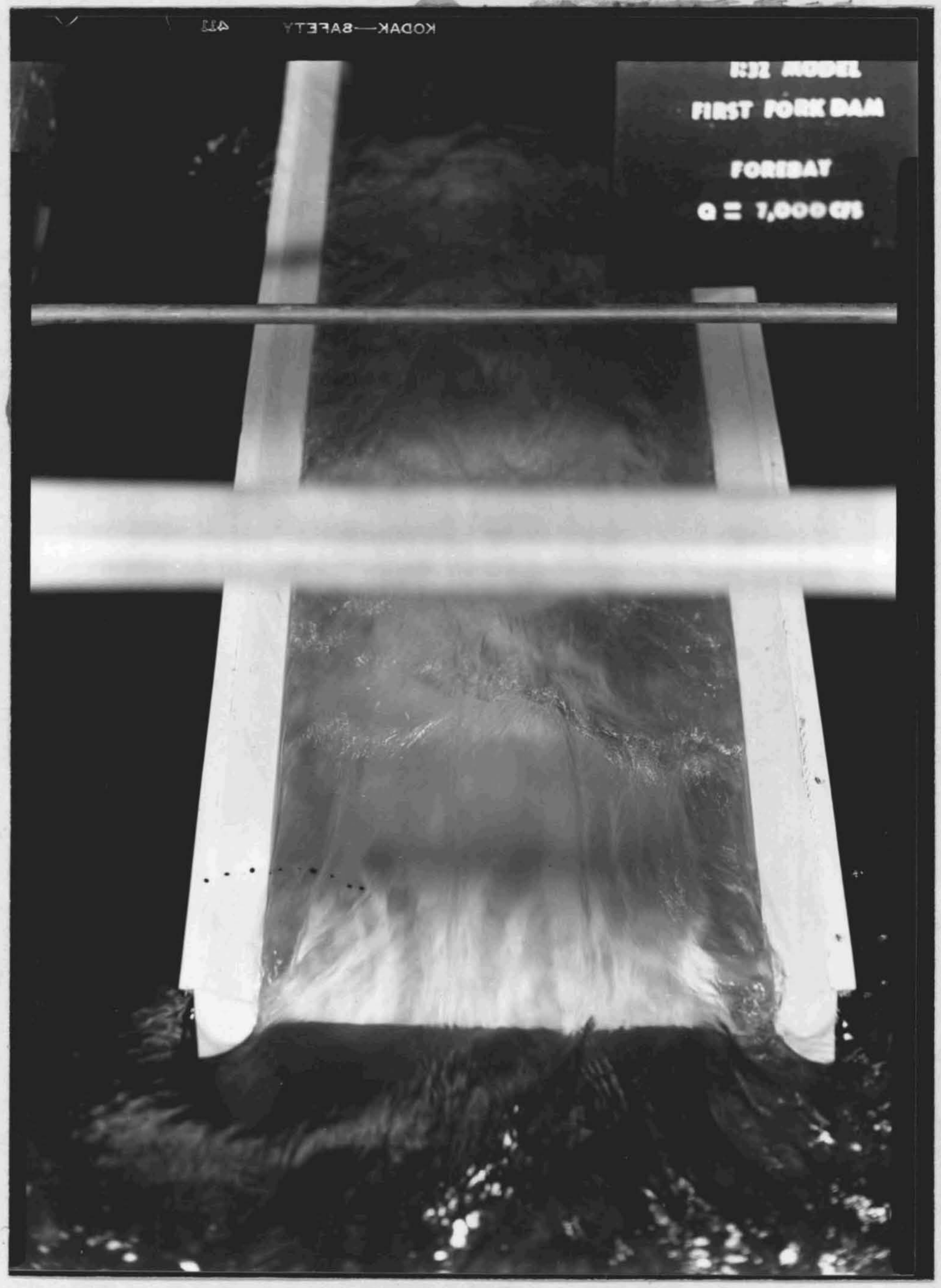


REVISED DESIGN

FOREBAY

6,000 cfs

1:32 MODEL



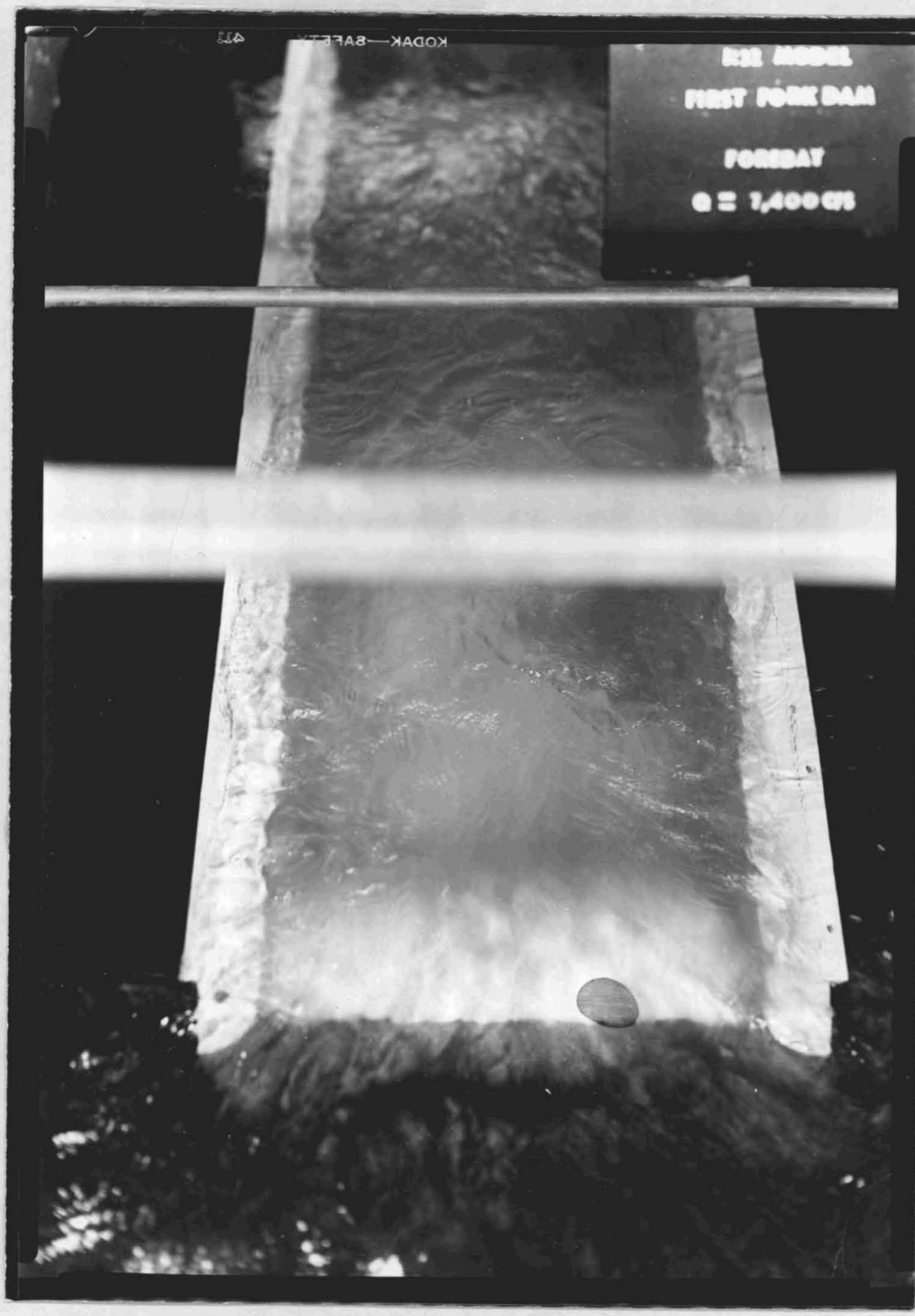
REVISED DESIGN

FOREBAY

7,000 cfs

1:32 MODEL

FIGURE 31



REVISED DESIGN

FOREBAY

7,400 cfs

POOL LEVEL $\cong$ FOREBAY LEVEL

1:32 MODEL

All Data is Given in Terms of Prototype Values.

FIRST FORK OUTLET STRUCTURE
1:32 MODEL, TEST DATA

TABULATION OF FREE SURFACE WATER LEVELS--WITHOUT FOREBAY

RUN NO:	DISCHARGE, CFS	RESERVOIR POOL	REMARKS
S-9	2,000	907.	Open channel flow throughout, noticeable drawdown at intake, conduit half full.
S-8	3,000	908.	Point of transition between open and full flow in gate chamber, drawdown at intake.
S-7	4,100	912. to 910.	Flow in conduit unstable, large amount of air from intake, jump is present at times in conduit--accentuated by relatively small size of model entrance tank.
S-2	4,400	911.	Periodic gulping of air at intake at about 2-3 sec. intervals, slight amount of air through vents, bubbles traveling length of conduit neither large nor continuous--action is mild.
S-6	4,900	913.	No air drawn from intake or vents, water in vents at El. 907.5.
S-5	5,300	916.	
S-4	5,700	919.	
S-3	6,100	923.	
S-1	6,500	926.	

For all higher heads, check runs were identical with the data given in Figure 14, with the forebay. The amount of air drawn from the air vents and intake for these runs was practically the same as that for the similar runs with the forebay. The critical range of 4,100 to 4,300 cfs was accentuated here by the restriction in stage regulation afforded by the 4' x 10' model entrance tank.

FIGURE 33

All Data is Given in Terms of Prototype Values.

5 & 6 August 1952

FIRST FORK OUTLET STRUCTURE
1:32 MODEL, TEST DATA

BOTH GATES OPEN--NO FOREBAY

TAP NO.	POSITION (For Details see Runs 1 to 13)	PRESSURE HEAD RELATIVE TO GIVEN ELEVATION OF TAP: RUN S-7 RESERV. POOL 912. 4,100 CFS	RUN S-2 RESERV. POOL 911. 4,400 CFS
a-1	Left Wall	8.0	8.3
c-1	Left/Pier	10.3	10.9
t-1	Left Top	0.0	0.2
a-2	Left Wall	9.0	9.0
c-2	Left/Pier	9.3	9.3
a-3	Left Wall	8.0	8.3
b-3	Left Bottom	17.0	17.0
c-3	Left/Pier	8.3	8.7
t-3	Left Top	- 0.8	- 0.5
d-3	Right/Pier	8.0	8.7
e-3	Right Wall	8.0	8.7
a-4	Left Wall	7.7	8.0
t-4	Left Top	- 0.8	- 0.1
a-5	Left Wall	8.7	9.3
c-5	Left/Pier	9.3	9.3
a-6	Left Wall	7.4	7.7
b-6	Left Bottom	16.0	16.3
c-6	Left/Pier	7.7	7.4
t-6.5	Left Top	- 0.3	0.0
a-7	Left Wall	8.3	9.0
c-7	Left/Pier	9.0	8.7
a-8	Left Wall	7.1	7.4
b-8	Left Bottom	15.7	16.0
c-8	Left/Pier	7.4	7.4
d-8	Right/Pier	7.1	7.4
t-9	Left Top	- 0.3	- 0.3
a-10	Left Wall	7.1	7.4
b-11	Left Bottom	15.1	15.4
t-11	Left Top	- 0.6	- 0.6
a-12	Left Wall	7.1	7.4
c-12	Left/Pier	7.4	7.4
e-12	Right Wall	7.4	7.4
b-13	Left Bottom	14.4	14.4
c-13	Tip Splitter	6.7	7.1
a-14	Left Wall	6.4	6.4
e-14	Right Wall	6.4	6.4
b-15	Conduit Invert	(unstable)	11.5
b-16	Conduit Invert		11.2
b-17	Conduit Invert		11.9
b-18	Conduit Invert		12.8
b-19	Conduit Invert		12.8
b-20	Conduit Invert		12.8

FIGURE 34

All Data is Given in Terms of Prototype Values.

5 & 6 August 1952

FIRST FORK OUTLET STRUCTURE
1:32 MODEL, TEST DATA

BOTH GATES OPEN--NO FOREBAY

TAP NO.	POSITION (For Details see Runs 1 to 13)	PRESSURE HEAD RELATIVE TO GIVEN ELEVATION OF TAP: RUN S-5 RESERV. POOL 916. 5,300 CFS	RUN S-1 RESERV. POOL 926. 6,500 CFS
a-1	Left Wall	12.5	19.5
c-1	Left/Pier	14.7	23.7
t-1	Left Top	3.4	10.1
a-2	Left Wall	13.1	20.2
c-2	Left/Pier	13.1	20.8
a-3	Left Wall	11.9	19.2
b-3	Left Bottom	20.8	28.2
c-3	Left/Pier	12.2	19.5
t-3	Left Top	2.8	9.2
d-3	Right/Pier	12.2	19.2
e-3	Right Wall	11.9	18.9
a-4	Left Wall	11.6	18.2
t-4	Left Top	3.1	9.7
a-5	Left Wall	13.5	21.4
c-5	Left/Pier	13.1	21.8
a-6	Left Wall	10.6	17.0
b-6	Left Bottom	19.9	26.6
c-6	Left/Pier	10.6	17.0
t-6.5	Left Top	3.2	9.9
a-7	Left Wall	12.8	20.2
c-7	Left/Pier	12.5	20.2
a-8	Left Wall	10.6	17.0
b-8	Left Bottom	19.2	26.2
c-8	Left/Pier	10.3	16.6
d-8	Right/Pier	10.3	16.6
t-9	Left Top	2.9	9.9
a-10	Left Wall	10.9	17.2
b-11	Left Bottom	18.6	25.0
t-11	Left Top	2.6	9.0
a-12	Left Wall	10.6	17.0
c-12	Left/Pier	10.3	17.0
e-12	Right Wall	10.6	16.6
b-13	Left Bottom	17.6	24.0
c-13	Tip Splitter	9.9	16.0
a-14	Left Wall	9.3	14.7
e-14	Right Wall	9.0	14.7
b-15	Conduit Invert	13.2	17.3
b-16	Conduit Invert	12.8	15.5
b-17	Conduit Invert	12.3	14.6
b-18	Conduit Invert	12.3	13.9
b-19	Conduit Invert	12.3	13.1
b-20	Conduit Invert	12.0	11.9

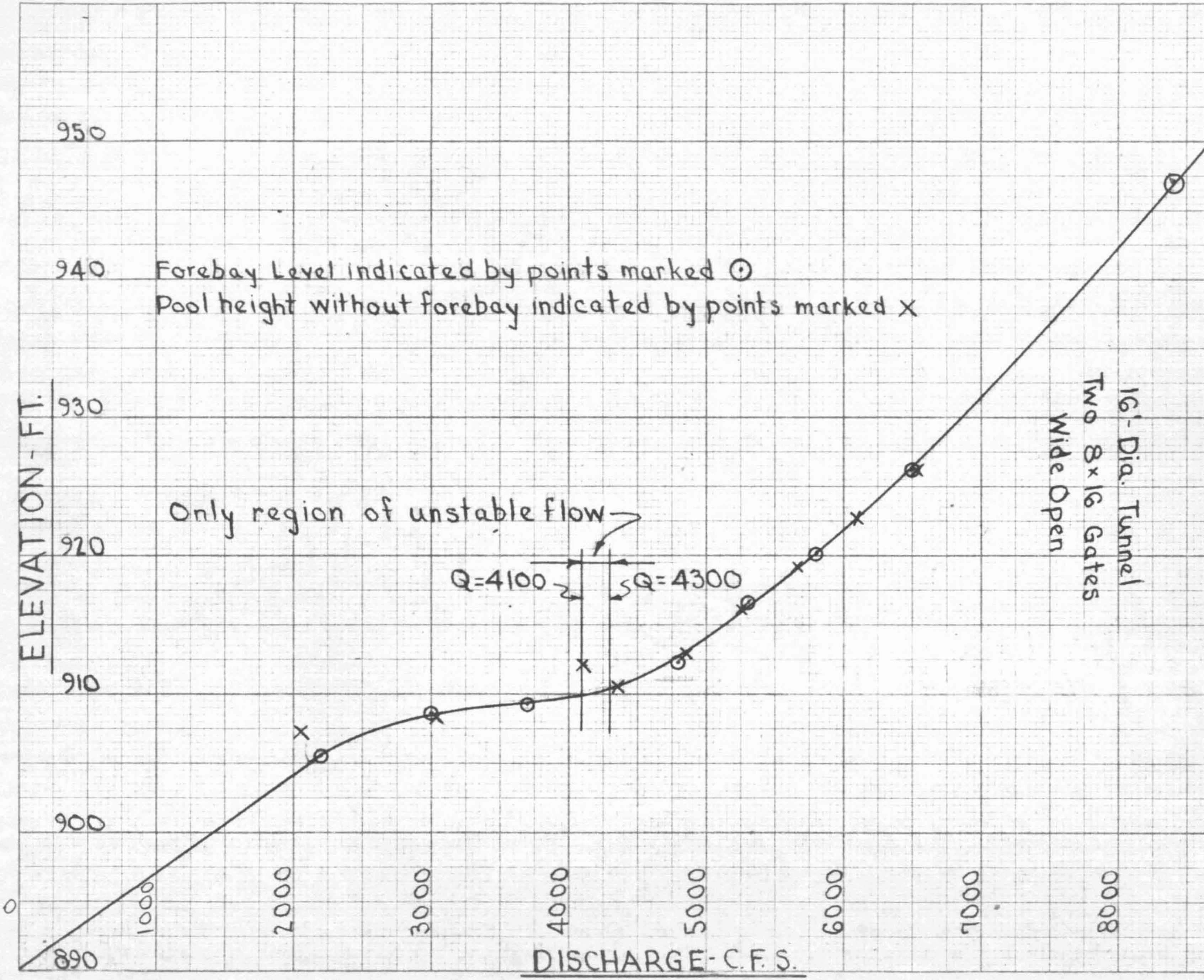
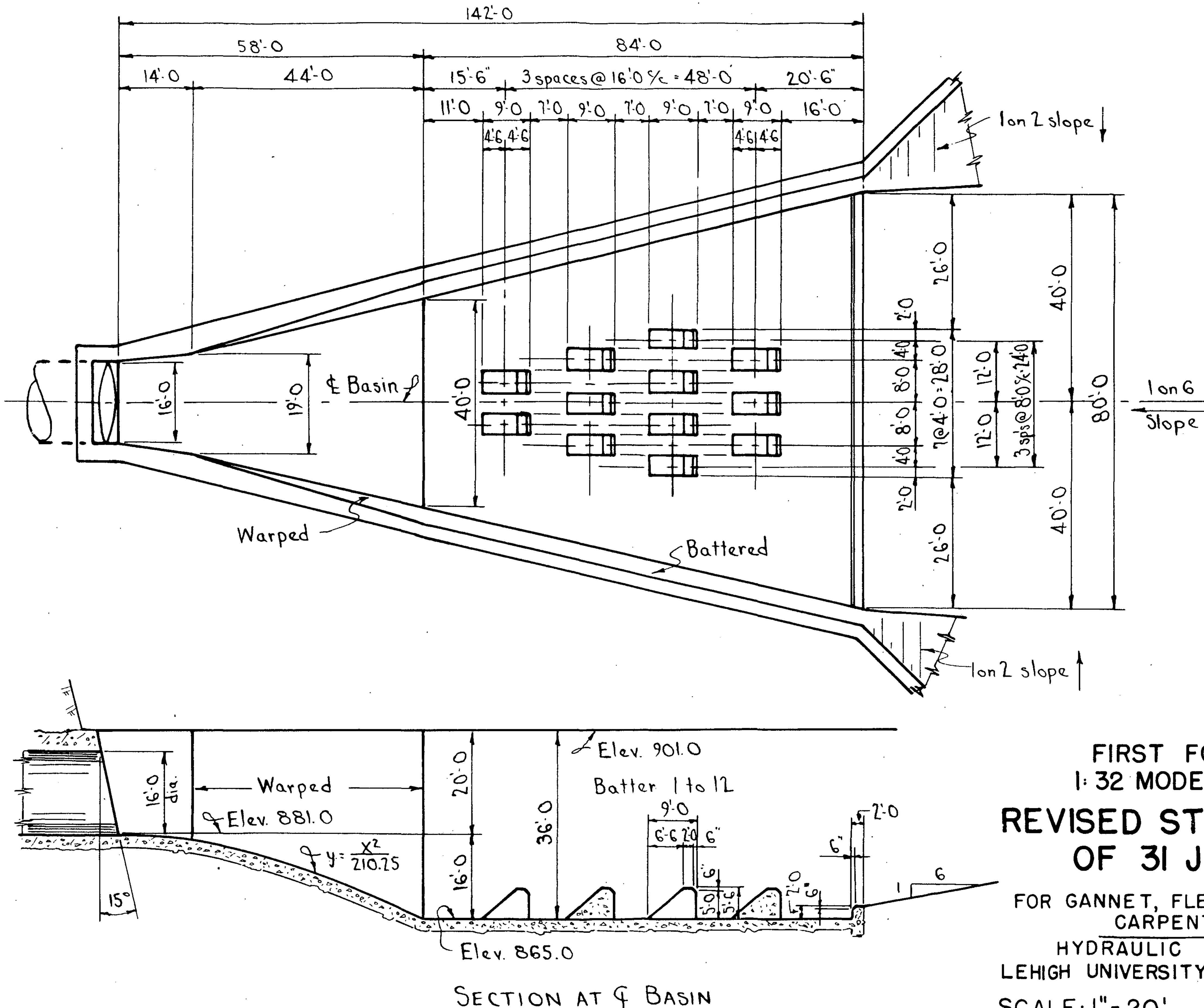


FIGURE 35

FIRST FORK OUTLET STRUCTURE

PLOT OF APPROACH DEPTHS WITH & WITHOUT FOREBAY

FIGURE 36



FIRST FORK DAM
1:32 MODEL DETAILS

REVISED STILLING POOL OF 31 JULY 1952

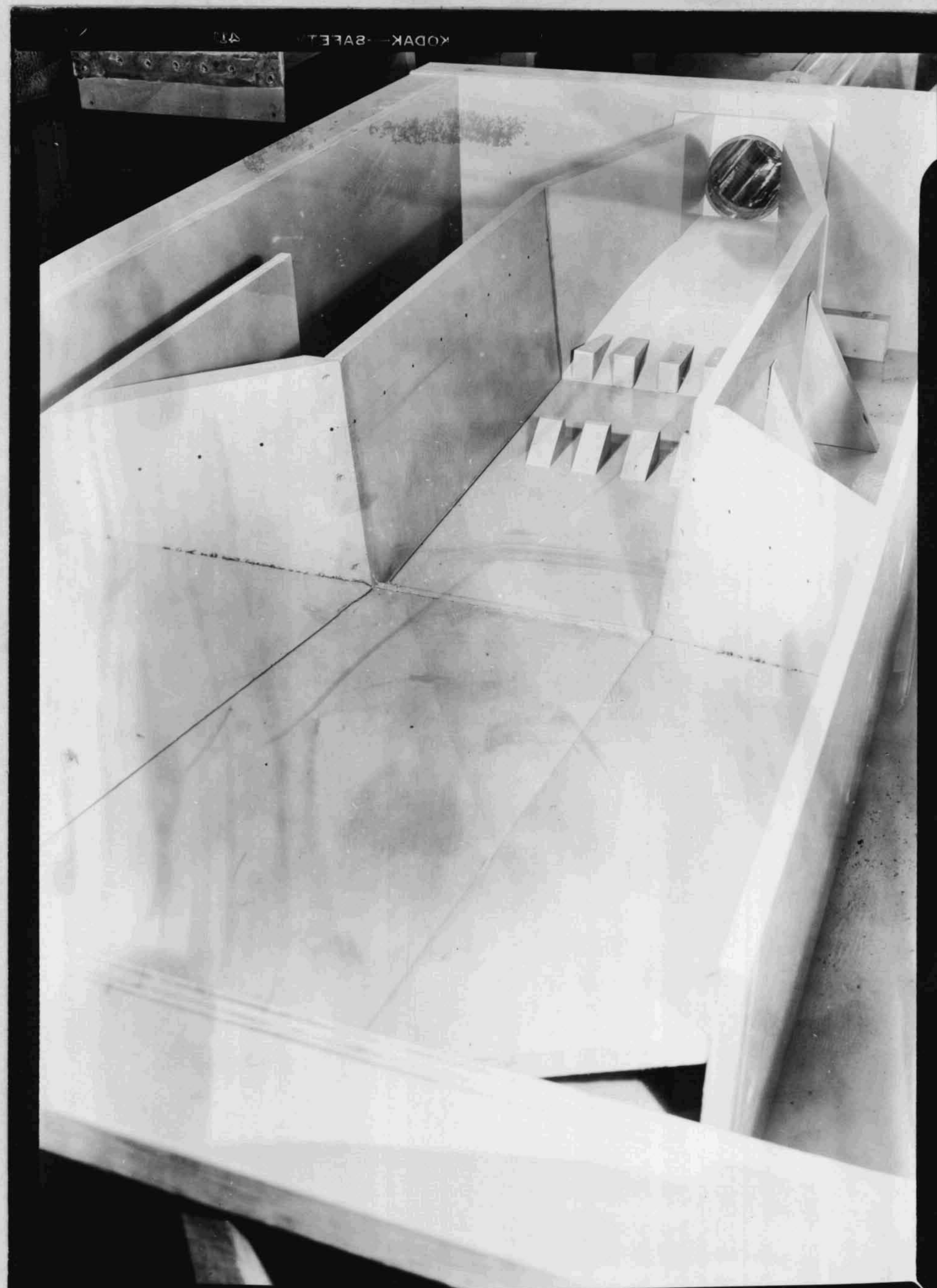
FOR GANNET, FLEMING, CORDDRY, AND CARPENTER INC.

HYDRAULIC LABORATORY
LEHIGH UNIVERSITY BETHLEHEM, PA.

SCALE: 1" = 20'

C.T.-51

FIGURE 37



ORIGINAL DESIGN

STILLING POOL

1:32 MODEL

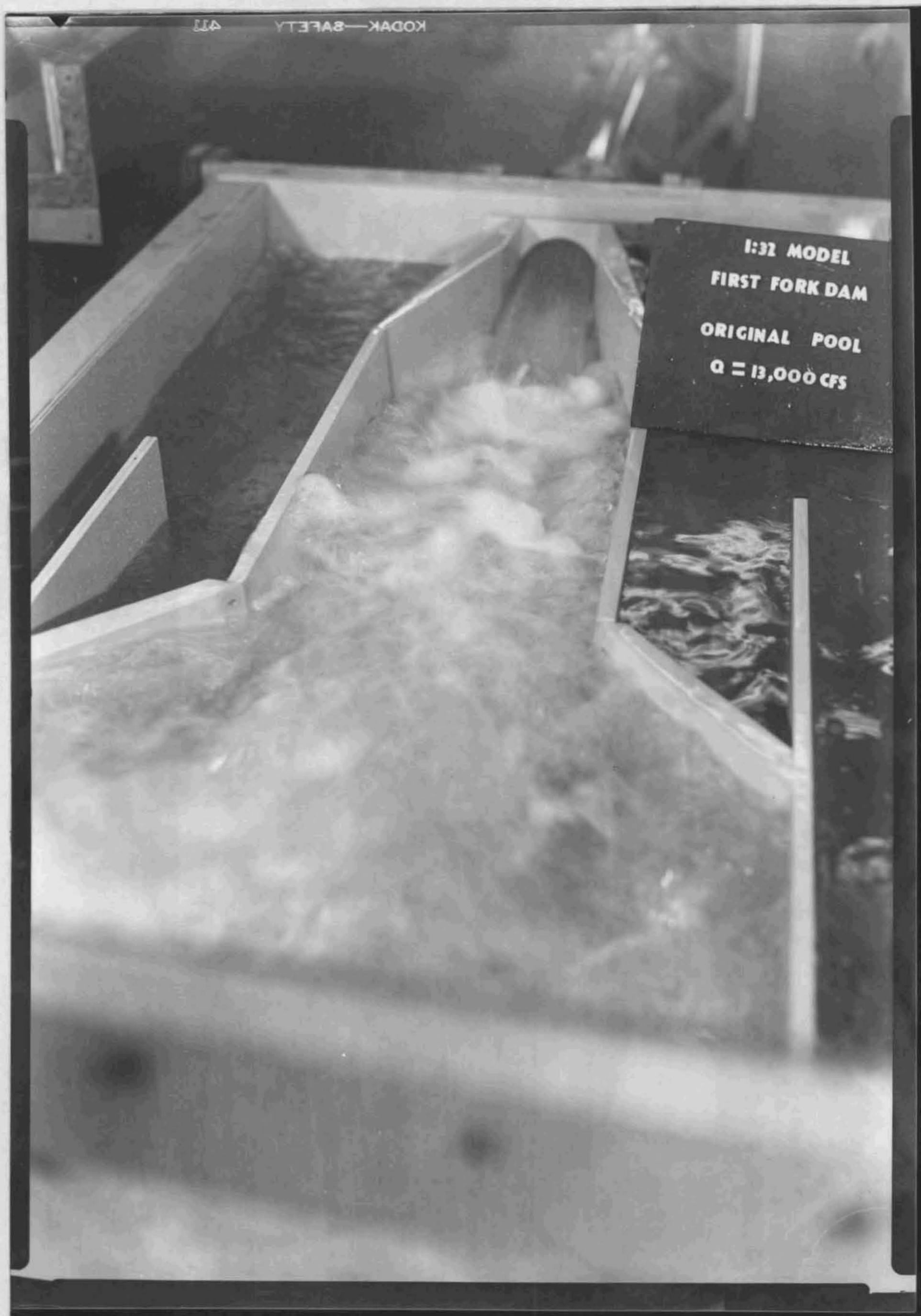
ORIGINAL DESIGN

STILLING POOL

12,000 cfs

1:32 MODEL

FIGURE 39

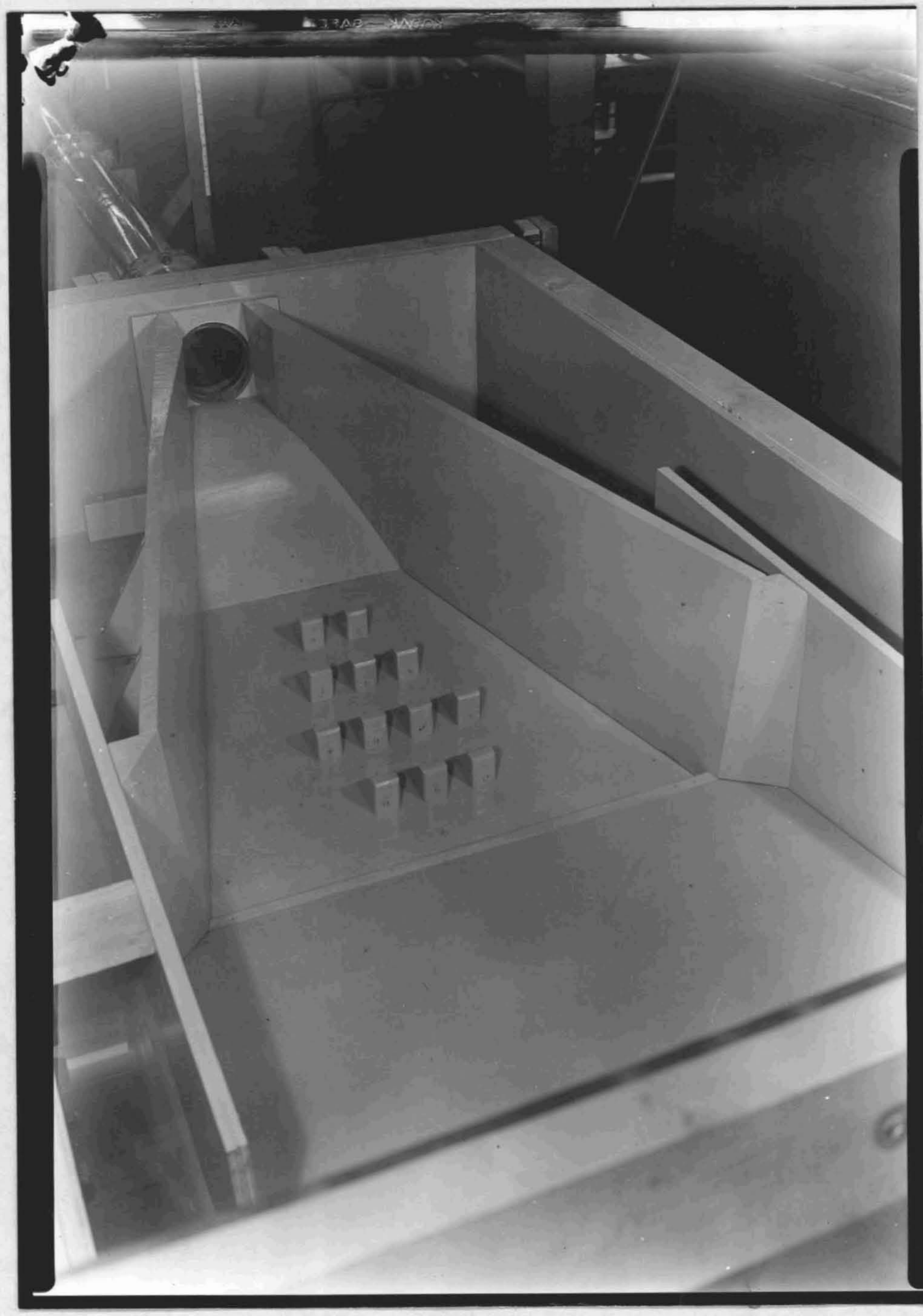


ORIGINAL DESIGN

STILLING POOL

13,00 cfs

1:32 MODEL

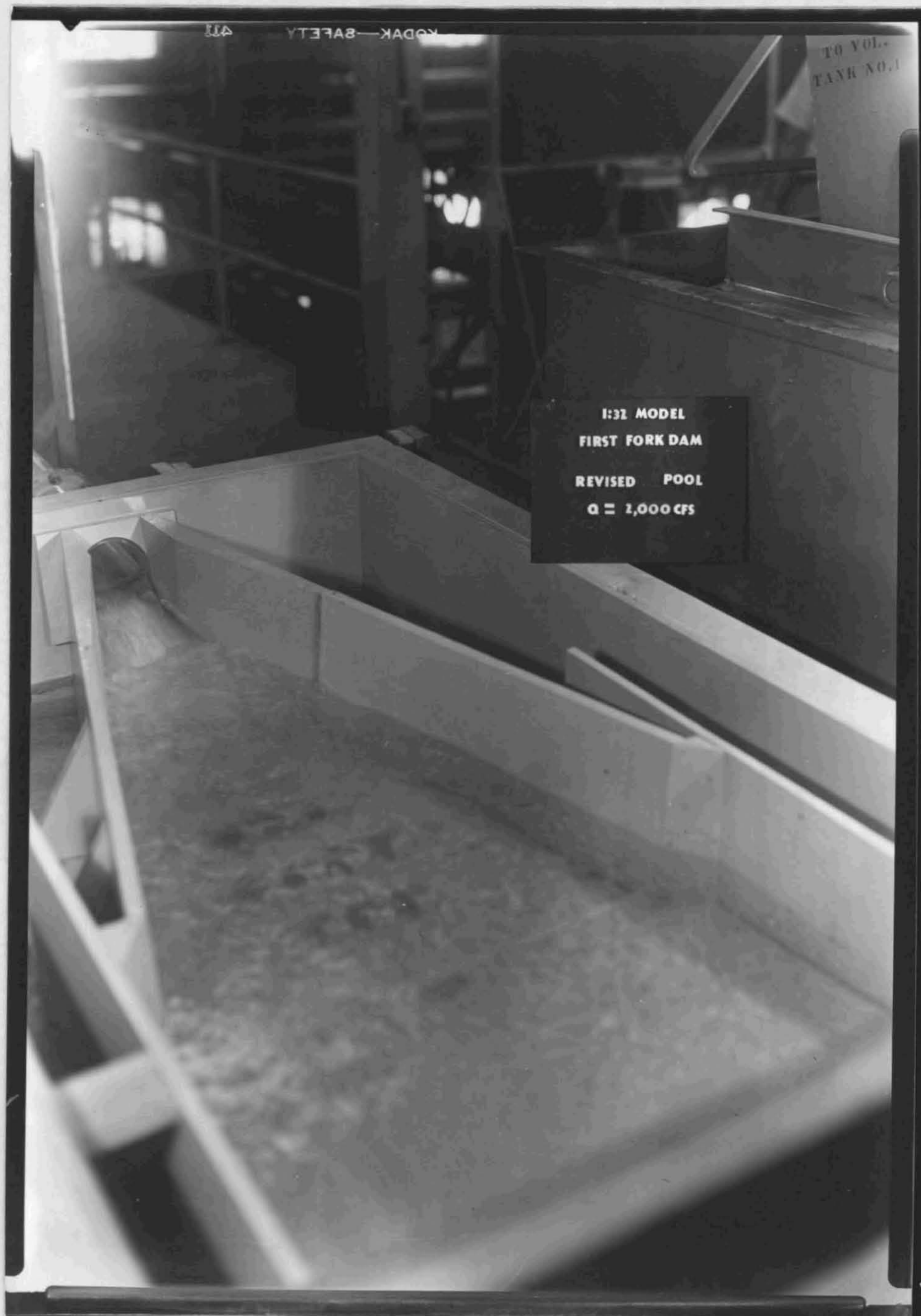


REVISED

STILLING POOL

1:32 MODEL

FIGURE 41



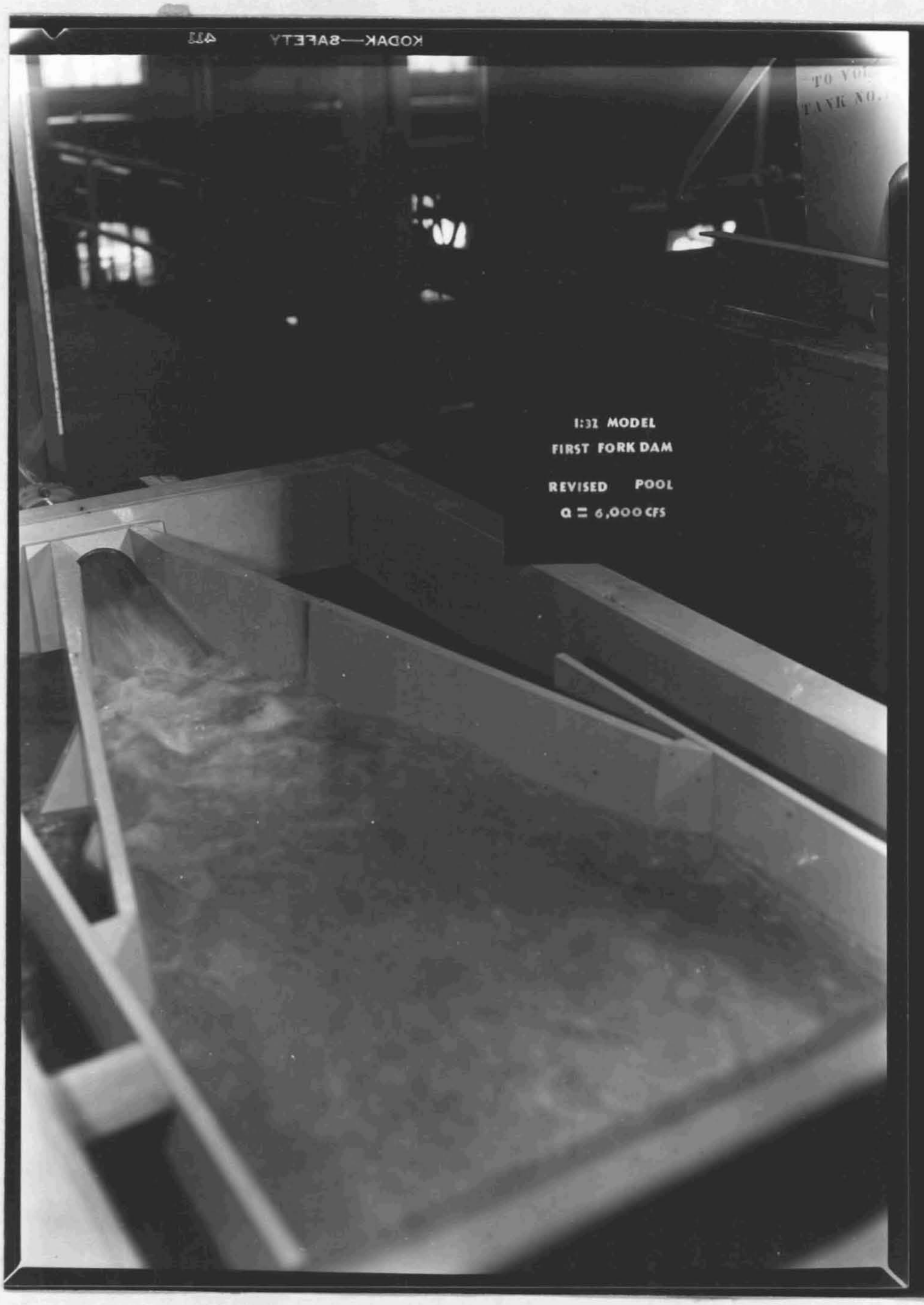
REVISED

STILLING POOL

2,000 cfs

1:32 MODEL

FIGURE 42



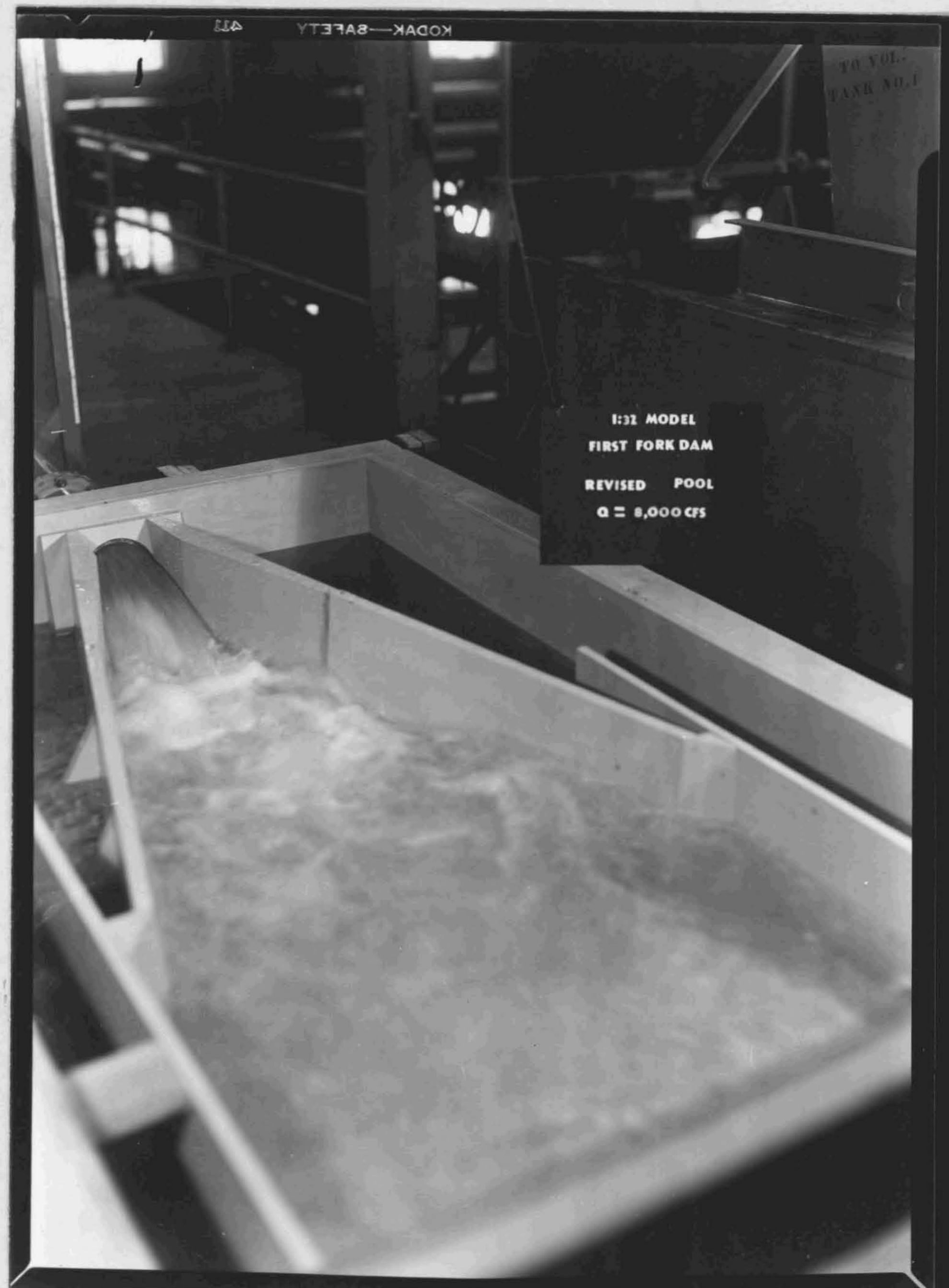
REVISED

STILLING POOL

6,000 cfs

1:32 MODEL

FIGURE 43



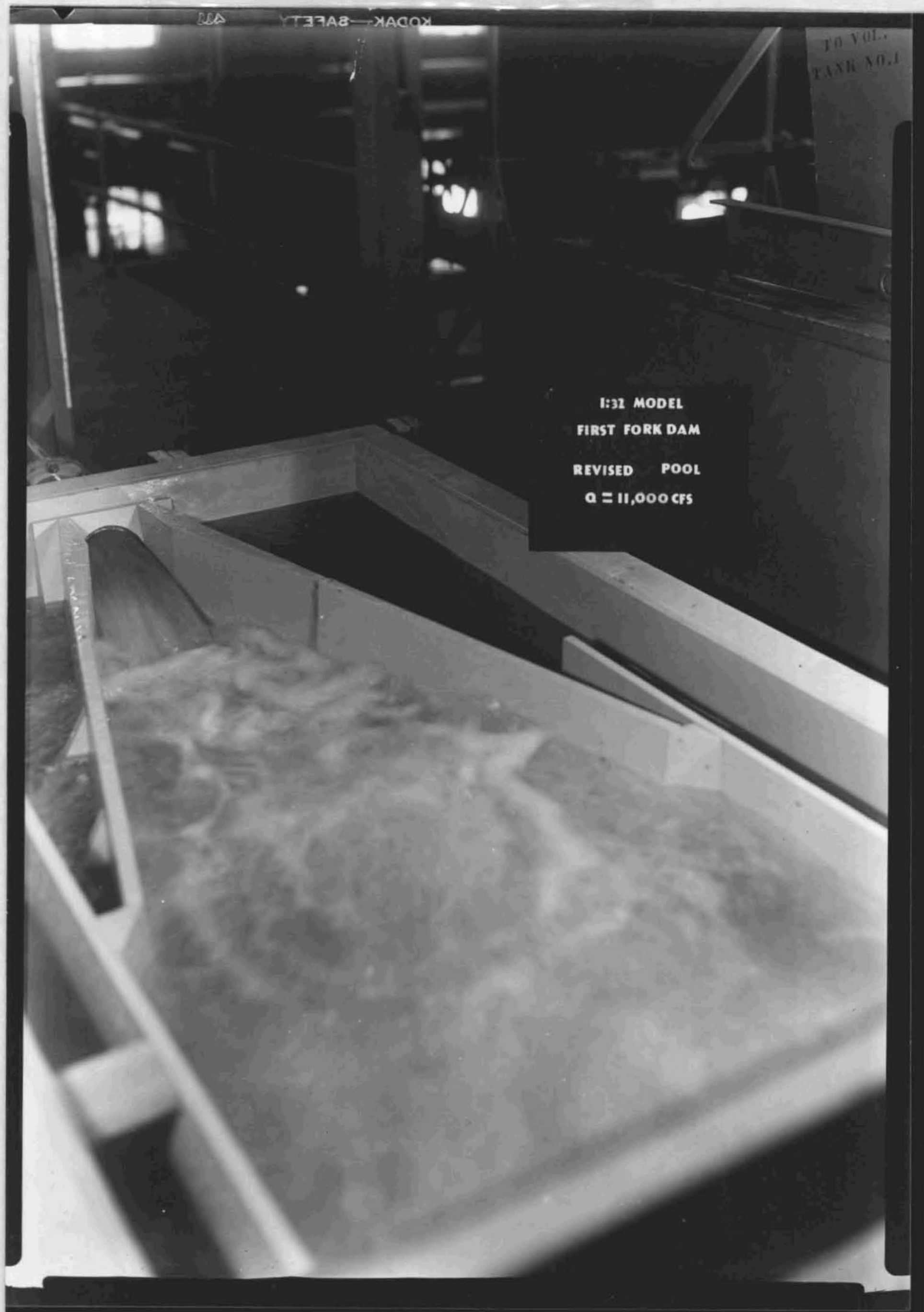
REVISED

STILLING POOL

8,000 cfs

1:32 MODEL

FIGURE 44



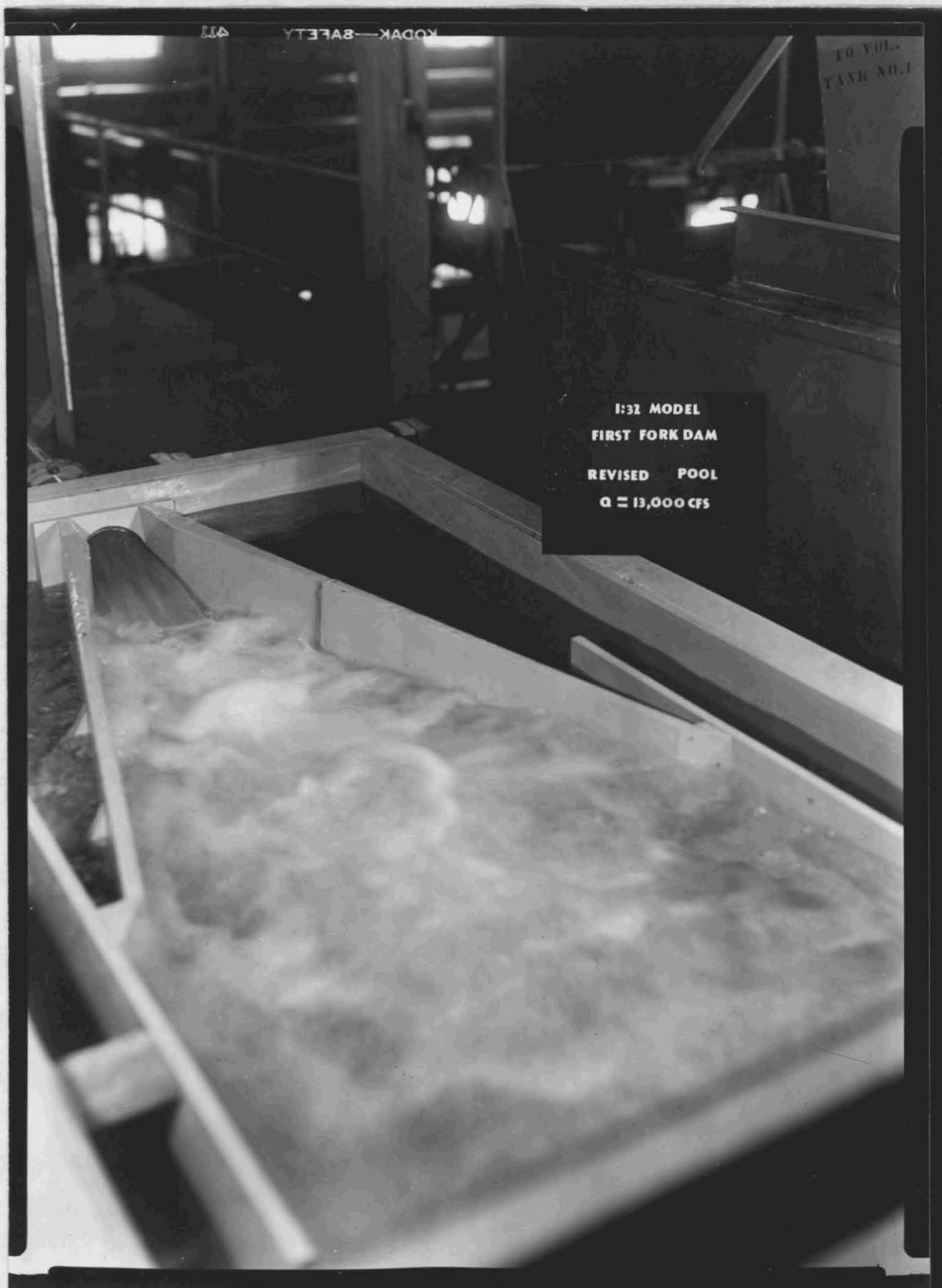
REVISED

STILLING POOL

11,000 cfs

1:32 MODEL

FIGURE 45



REVISED

STILLING POOL

13,000 cfs

1:32 MODEL

All Data is Given in Terms of Prototype Values.

FIRST FORK OUTLET STRUCTURE
1:32 MODEL, TEST DATA

STILLING POOL

ORIGINAL DESIGN

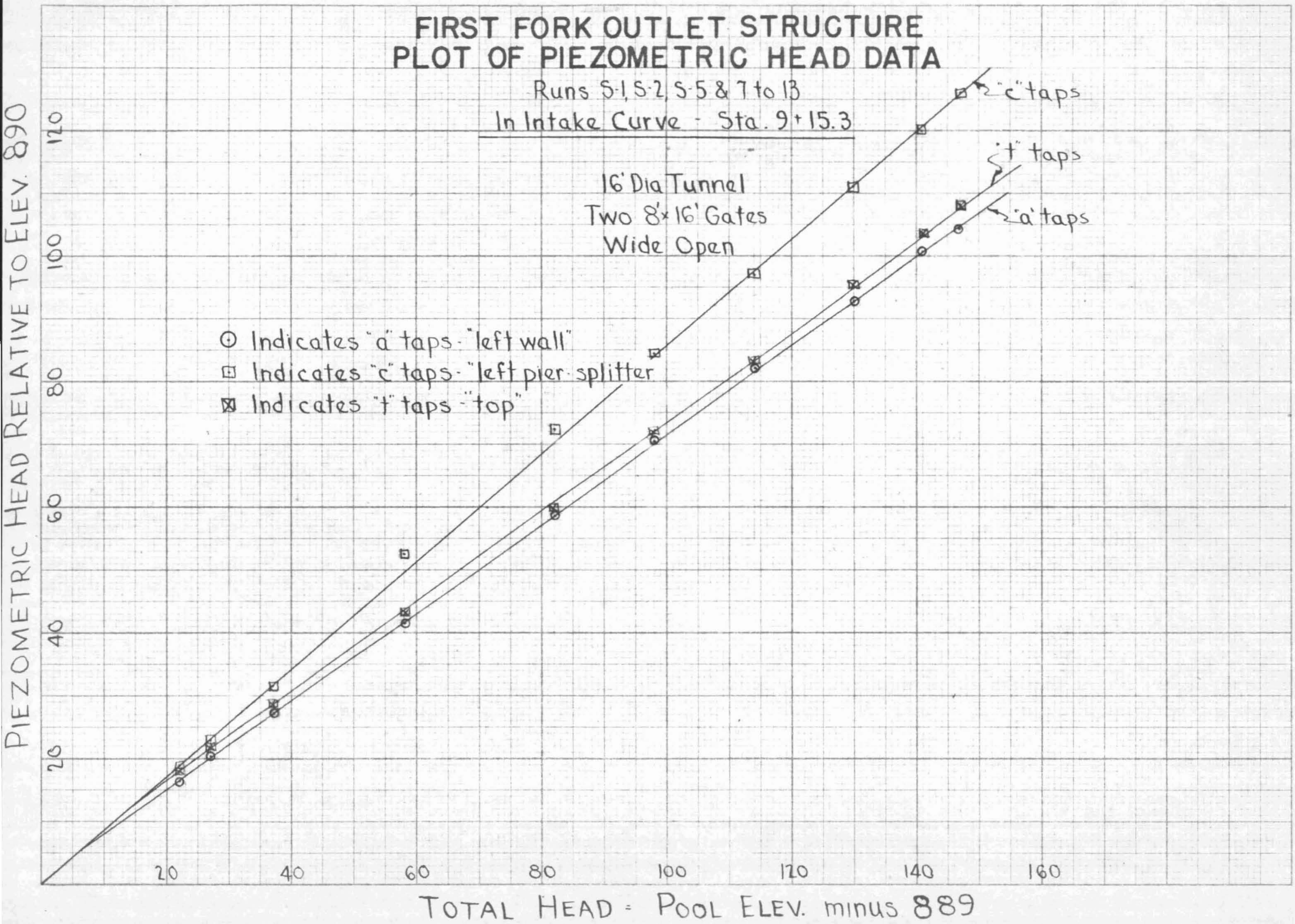
Discharge	Depth at End of Side Walls Station 21/35.	Remarks
2,200	23'	Jet submerged within vertical curve. Depth of Flow Between Side Walls fairly uniform.
3,000	24'	Ditto.
4,800	25.5'	Ditto.
5,300	25.5'	Ditto.
5,800	25.5'	Ditto.
6,500	27'	Action becoming violent.
8,400	27'	Violent action in pool. Jet continues practically undiminished to end of pool.
10,200	30'	Free jet extends almost to end of vertical curve--very high exit velocity over sill-depth at Sta. 20/55, 21'.
11,100	32'	Ditto.
12,100	32'	Ditto, except that free jet springs clear of tapered walls. Very high exit velocity, especially along bottom, throughout pool. See photo.

Beyond 11,000 cfs, jet completely uncontrolled by pool (see also photo for 13,000 cfs). High oscillating velocity of jet at end sill impossible of measurement. Sill blocks have little or no effect upon jet--jet continues practically undiminished in velocity and area to end sill.

REVISED DESIGN

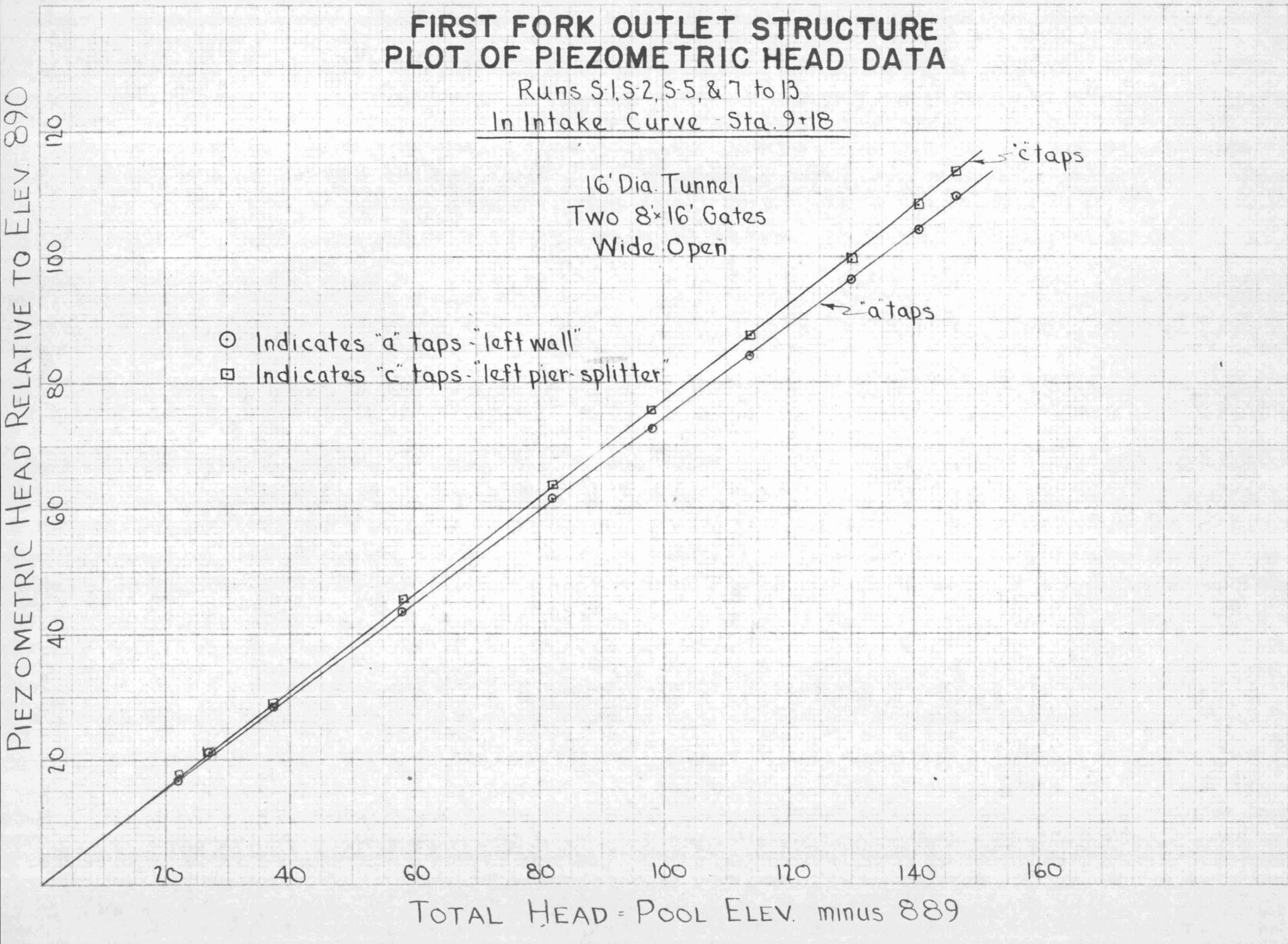
Discharge	Depth at End of Side Walls Station 21/35.	Depth at Beginning of Side Walls Station 20/55.	Measured Max. Vel. over End Sill*
2,000 cfs	18.5'	18.'	non-readable
6,000	22.5'	19.'	4.5 fps
8,000	23.'	19.'	5.7 fps
11,000	25.5'	21.5'	9.0 fps
13,000	32.0'	25.5'	13.5 fps approx.

* The points of maximum velocity were about 20-feet in from the ends of the walls on either side, and about 1/4 to 1/3 of the depth, from the floor. These are equivalent prototype velocities. (See photographs of above five runs.)



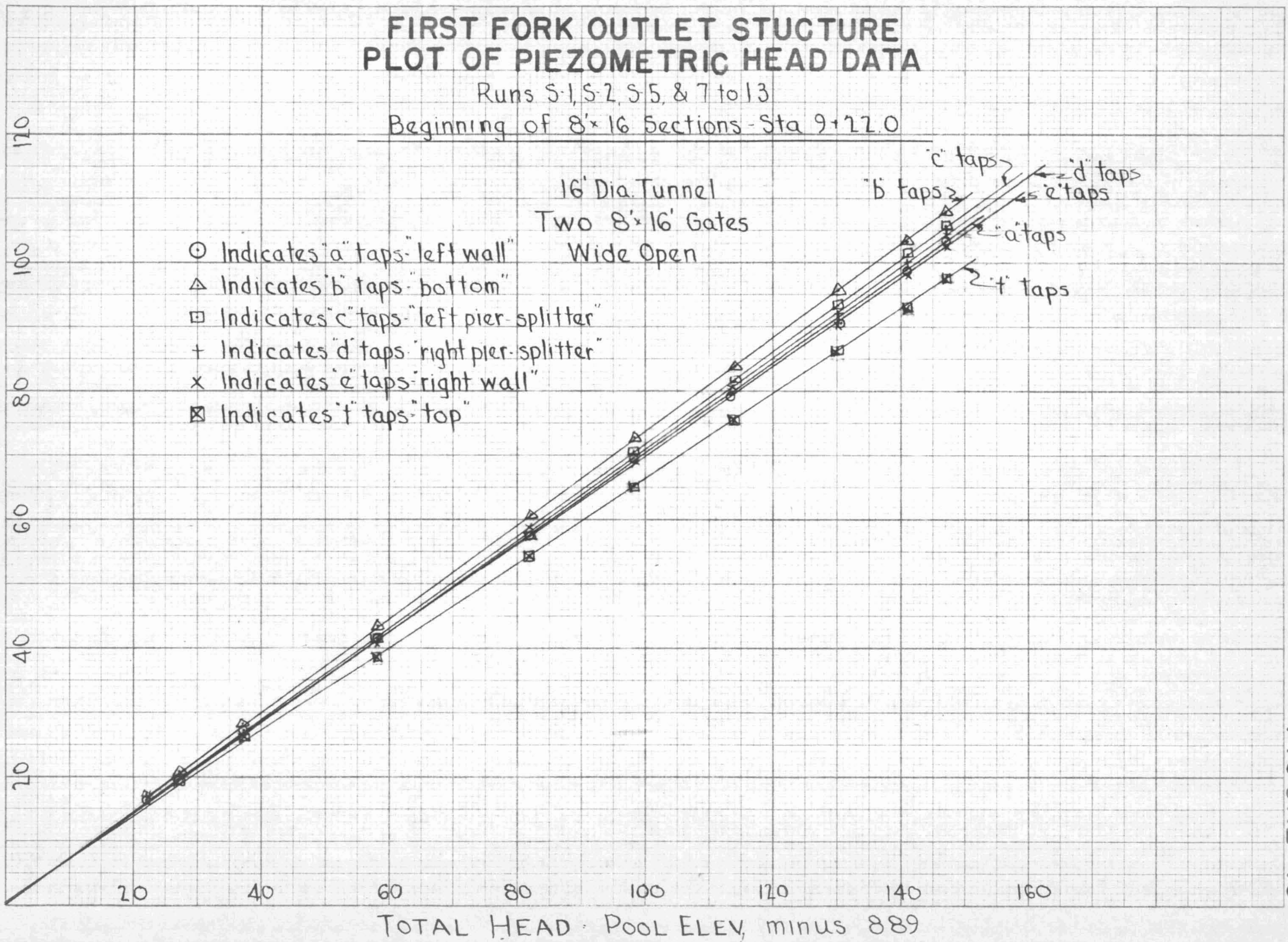
FIRST FORK OUTLET STRUCTURE
PLOT OF PIEZOMETRIC HEAD DATA
Runs S-1, S-2, S-5 & 7 to 13
In Intake Curve - Sta. 9+15.3
16' Dia Tunnel
Two 8'x16' Gates
Wide Open
"c" taps
"t" taps
"a" taps
Indicates "a" taps - "left wall"
Indicates "c" taps - "left pier splitter"
Indicates "t" taps - "top"
PIEZOMETRIC HEAD RELATIVE TO ELEV. 890
TOTAL HEAD = POOL ELEV. minus 889
20
40
60
80
100
120
140
160

FIGURE 47



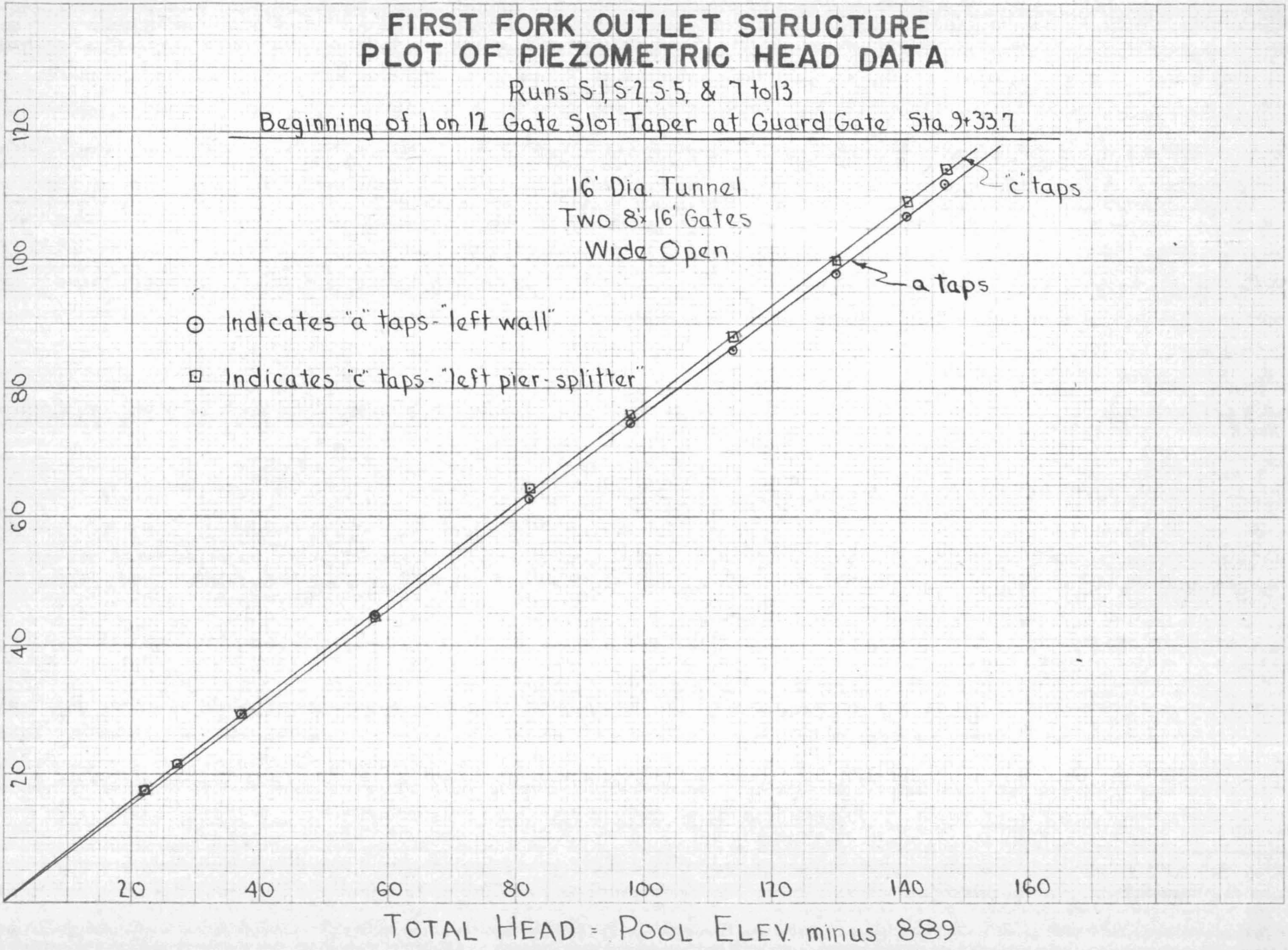
FIRST FORK OUTLET STRUCTURE
PLOT OF PIEZOMETRIC HEAD DATA
Runs S-1, S-2, S-5, & 7 to 13
In Intake Curve - Sta. 9+18
16' Dia. Tunnel
Two 8'×16' Gates
Wide Open
"c" taps
"a" taps
Indicates "a" taps - "left wall"
Indicates "c" taps - "left pier-splitter"
PIEZOMETRIC HEAD RELATIVE TO ELEV. 890
TOTAL HEAD = POOL ELEV. minus 889
20
40
60
80
100
120
140
160

FIGURE 48



FIRST FORK OUTLET STUCTURE
PLOT OF PIEZOMETRIC HEAD DATA
Runs S-1, S-2, S-5, & 7 to 13
Beginning of 8'× 16 Sections - Sta 9+22.0
16' Dia. Tunnel
Two 8'×16' Gates
Wide Open
⊙ Indicates "a" taps - "left wall"
△ Indicates "b" taps - "bottom"
⊡ Indicates "c" taps - "left pier-splitter"
+ Indicates "d" taps - "right pier-splitter"
× Indicates "e" taps - "right wall"
⊠ Indicates "f" taps - "top"
"c" taps
"d" taps
"b" taps
"e" taps
"a" taps
"f" taps
PIEZOMETRIC HEAD RELATIVE TO ELEV. 890
TOTAL HEAD - POOL ELEV. minus 889
20
40
60
80
100
120
140
160

FIGURE 49



FIRST FORK OUTLET STRUCTURE
PLOT OF PIEZOMETRIC HEAD DATA
Runs S-1, S-2, S-5, & 7 to 13
Beginning of 1 on 12 Gate Slot Taper at Guard Gate Sta. 9+33.7
16' Dia. Tunnel
Two 8'x16' Gates
Wide Open
Indicates "a" taps-"left wall"
Indicates "c" taps-"left pier-splitter"
"c" taps
a taps
PIEZOMETRIC HEAD RELATIVE TO ELEV. 890
TOTAL HEAD = POOL ELEV. minus 889
20
40
60
80
100
120
140
160

FIGURE 50

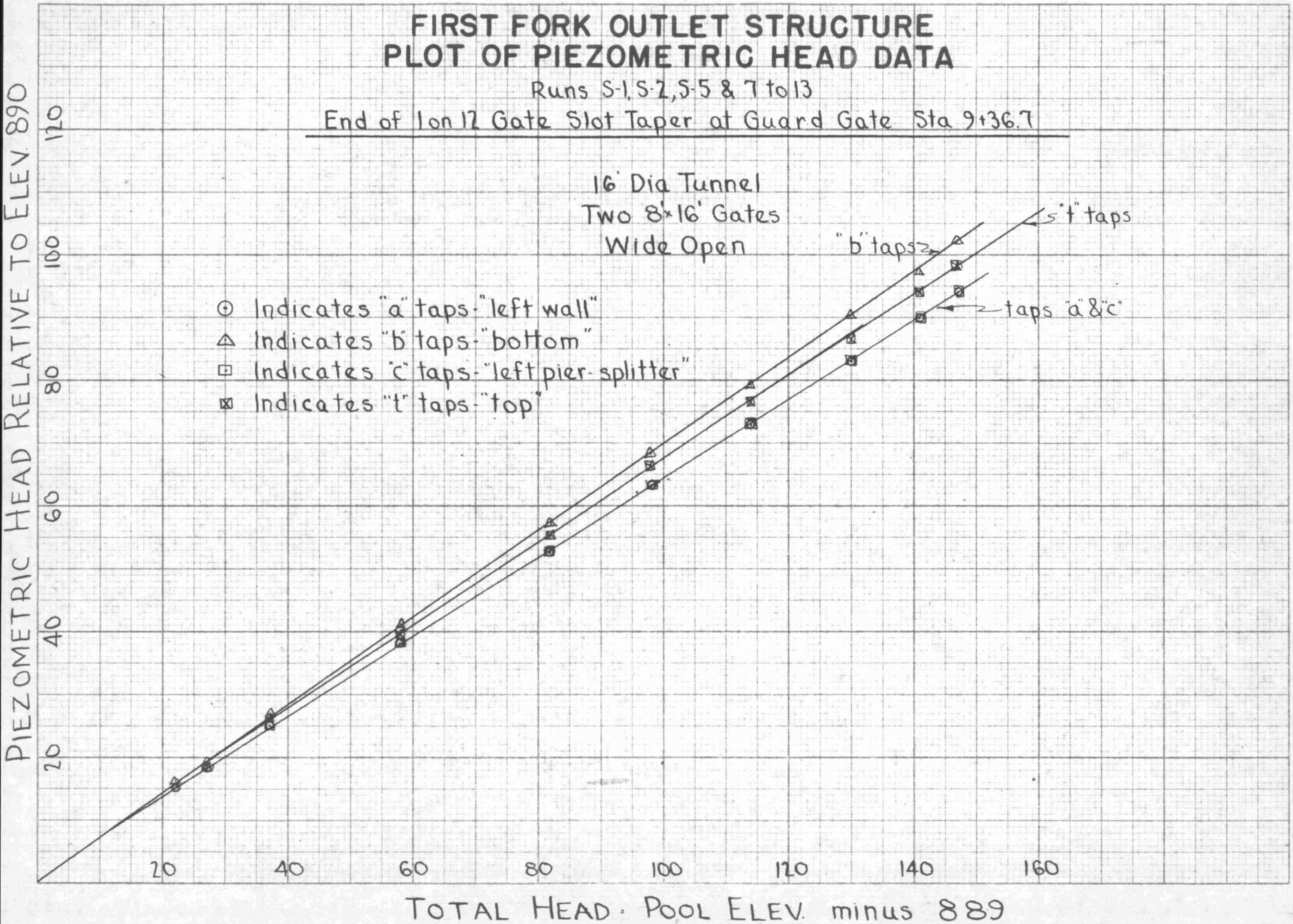

FIRST FORK OUTLET STRUCTURE
PLOT OF PIEZOMETRIC HEAD DATA
Runs S-1, S-2, S-5 & 7 to 13
End of 1 on 12 Gate Slot Taper at Guard Gate Sta 9+36.7
16' Dia Tunnel
Two 8'x16' Gates
Wide Open
"t" taps
"b" taps
taps "a" & "c"
Indicates "a" taps - "left wall"
Indicates "b" taps - "bottom"
Indicates "c" taps - "left pier-splitter"
Indicates "t" taps - "top"
PIEZOMETRIC HEAD RELATIVE TO ELEV. 890
20
40
60
80
100
120
140
160
TOTAL HEAD - POOL ELEV. minus 889

FIGURE 51

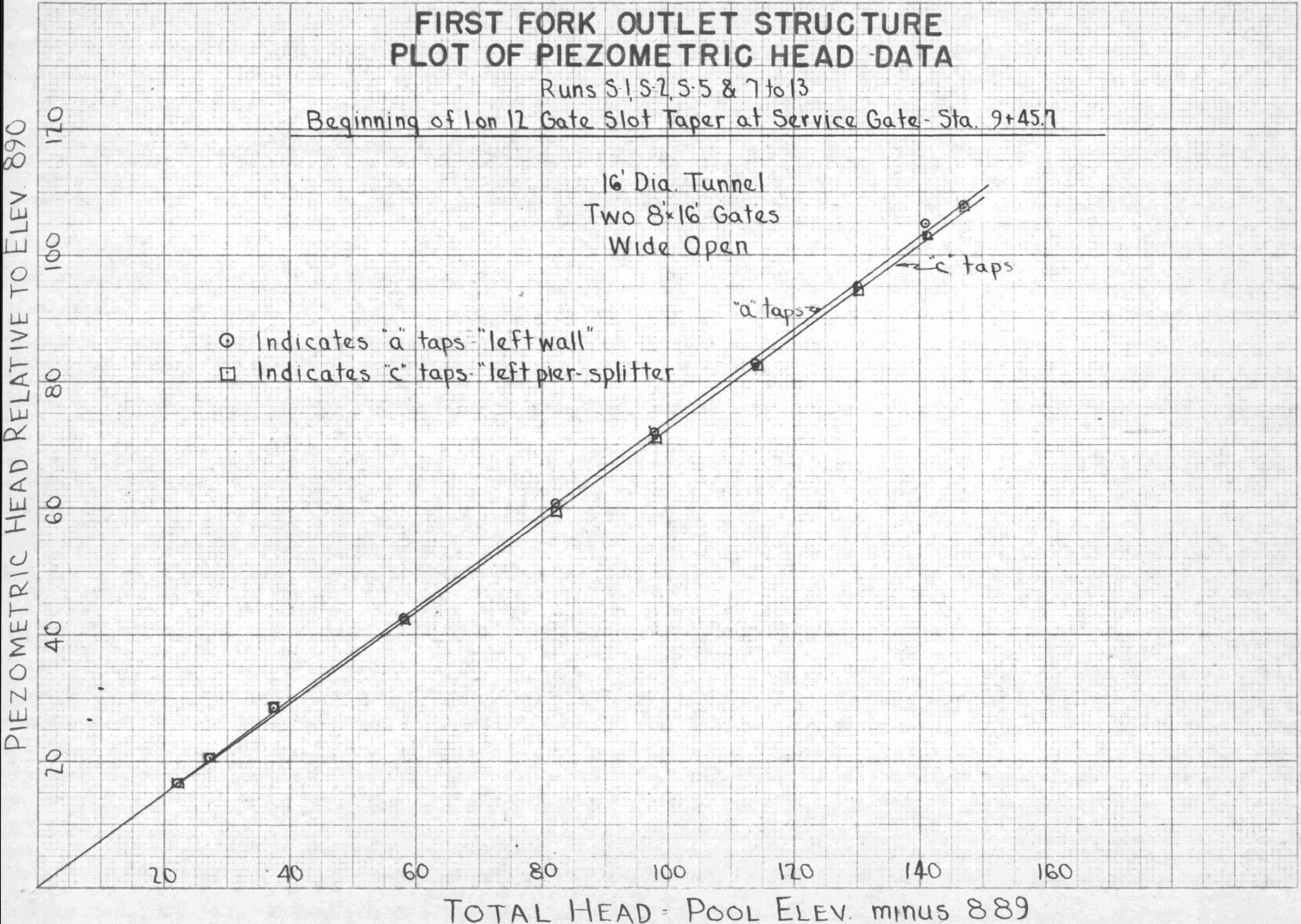
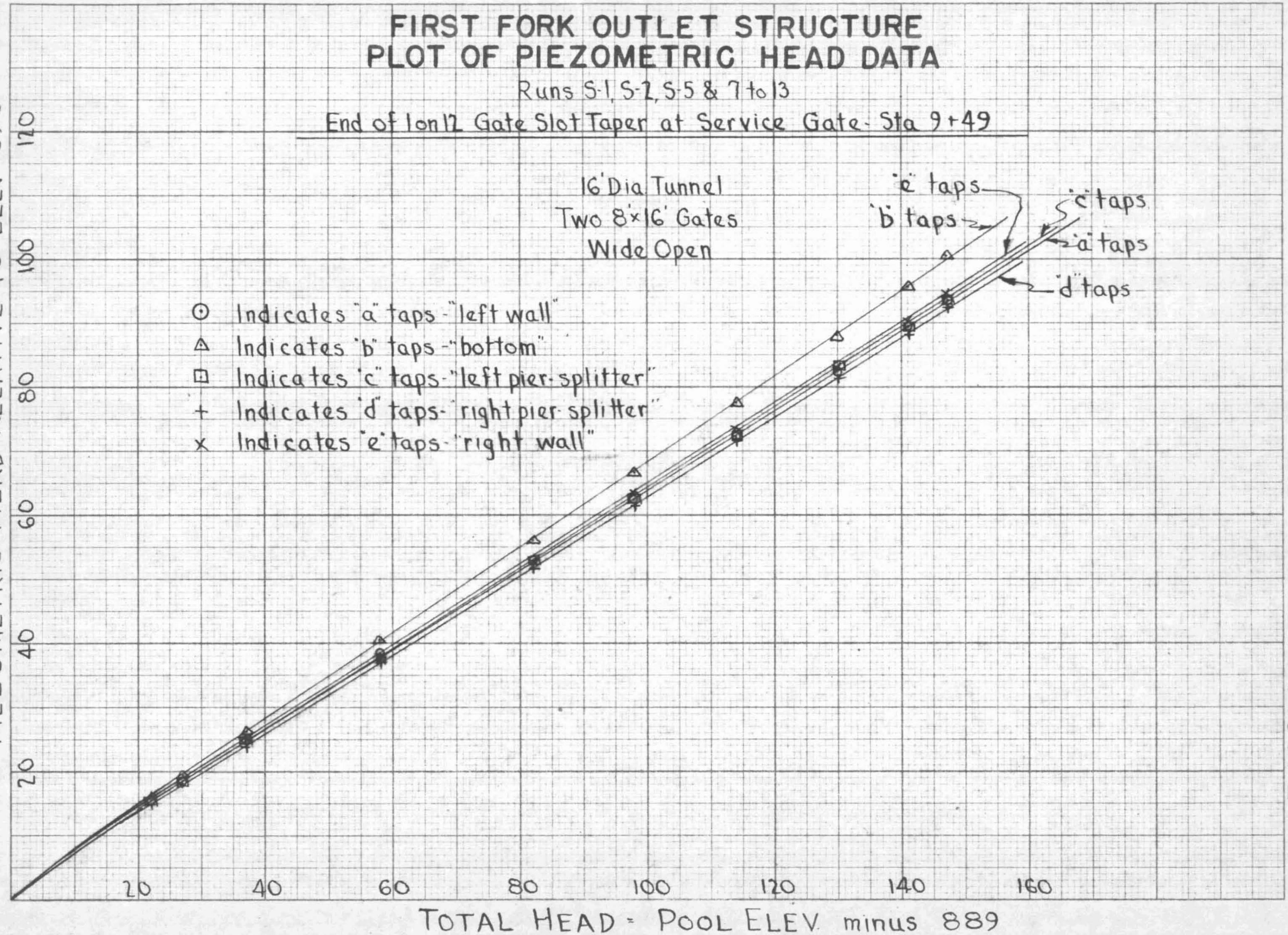

FIRST FORK OUTLET STRUCTURE
PLOT OF PIEZOMETRIC HEAD DATA
Runs S-1, S-2, S-5 & 7 to 13
Beginning of 1 on 12 Gate Slot Taper at Service Gate - Sta. 9+45.7
16' Dia. Tunnel
Two 8'×16' Gates
Wide Open
"c" taps
"a" taps
⊙ Indicates "a" taps - "left wall"
⊡ Indicates "c" taps - "left pier-splitter"
PIEZOMETRIC HEAD RELATIVE TO ELEV. 890
TOTAL HEAD = POOL ELEV. minus 889
20
40
60
80
100
120
140
160

FIGURE 52



FIRST FORK OUTLET STRUCTURE
PLOT OF PIEZOMETRIC HEAD DATA
Runs S-1, S-2, S-5 & 7 to 13
End of 1 on 12 Gate Slot Taper at Service Gate - Sta 9+49
16' Dia Tunnel
Two 8'×16' Gates
Wide Open
"e" taps
"b" taps
"c" taps
"a" taps
"d" taps
Indicates "a" taps - "left wall"
Indicates "b" taps - "bottom"
Indicates "c" taps - "left pier-splitter"
Indicates "d" taps - "right pier-splitter"
Indicates "e" taps - "right wall"
PIEZOMETRIC HEAD RELATIVE TO ELEV 890
TOTAL HEAD = POOL ELEV minus 889
20
40
60
80
100
120
140
160

FIGURE 53

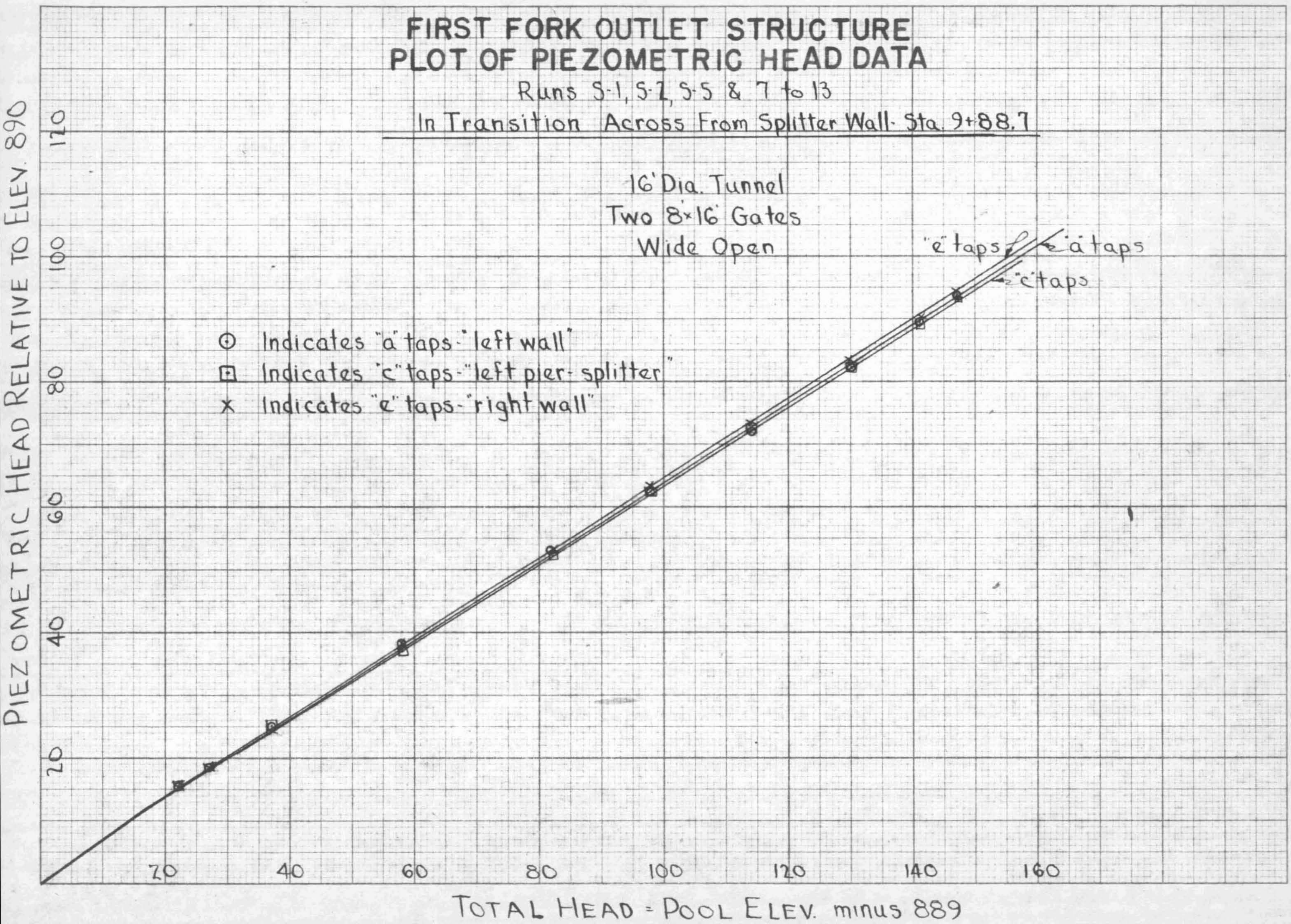
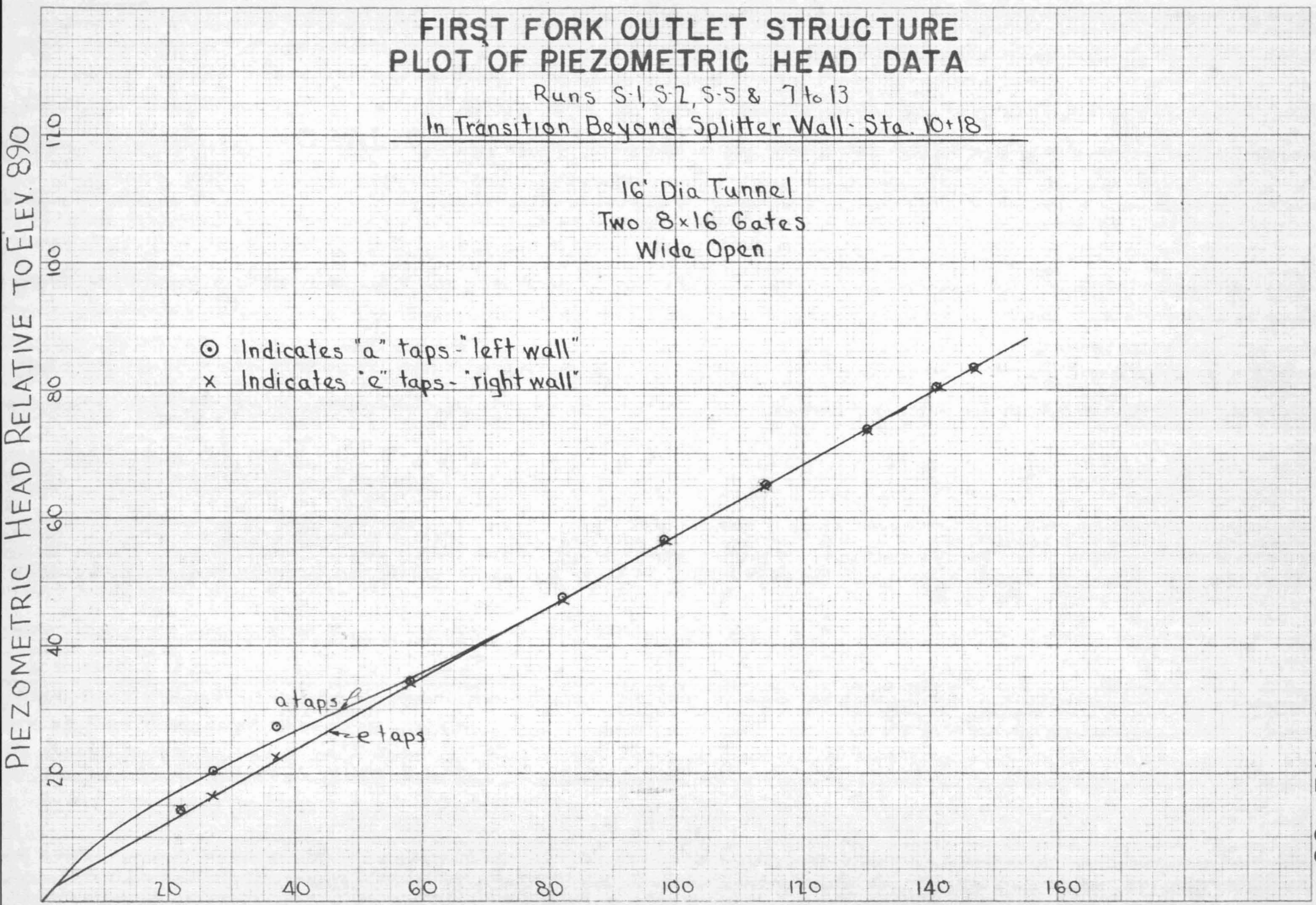

FIRST FORK OUTLET STRUCTURE
PLOT OF PIEZOMETRIC HEAD DATA
Runs S-1, S-2, S-5 & 7 to 13
In Transition Across From Splitter Wall- Sta. 9+88.7
16' Dia. Tunnel
Two 8'x16' Gates
Wide Open
"e" taps
"a" taps
"c" taps
⊙ Indicates "a" taps - "left wall"
⊡ Indicates "c" taps - "left pier- splitter"
× Indicates "e" taps - "right wall"
PIEZOMETRIC HEAD RELATIVE TO ELEV. 890
TOTAL HEAD = POOL ELEV. minus 889
20
40
60
80
100
120
140
160

FIGURE 54



FIRST FORK OUTLET STRUCTURE
PLOT OF PIEZOMETRIC HEAD DATA
Runs S-1, S-2, S-5 & 7 to 13
In Transition Beyond Splitter Wall - Sta. 10+18
16' Dia Tunnel
Two 8×16 Gates
Wide Open
⊙ Indicates "a" taps - "left wall"
× Indicates "e" taps - "right wall"
a taps
e taps
PIEZOMETRIC HEAD RELATIVE TO ELEV. 890
TOTAL HEAD = (POOL ELEV. minus 889)
20
40
60
80
100
120
140
160

FIGURE 55

ADDITIONAL STILLING BASIN TESTS
WITH A 1:32 MODEL,
FOR FIRST FORK
(SINNEMAHONING)
DAM

by

M. B. McPherson and H. S. Strausser

for

Gannett, Fleming, Corddry & Carpenter, Inc.

Harrisburg, Pa.

Fritz Engineering Laboratory
Department of Civil Engineering and Mechanics
Lehigh University
Bethlehem, Penna.

475-CT-51-B

15 October 1952

CT-51-B

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INTRODUCTION AND SYNOPSIS

In the basic report "Tests of a 1:32 Model of a Proposed Outlet Structure for the First Fork Dam" of June-September 1952, the status of the stilling basin design was undefined and the test results were inconclusive. Plans for an almost completely new stilling basin, a computed tailwater rating curve and authorization to build this new basin were issued on 28 August 1952 by Mr. Niederhoff. This basin, described in this report, has been arbitrarily designated the "Alternate Stilling Basin". Details relative to the four basic Alternate Basin arrangements reported here are given in Figure A-1. These are characterized by:

Alternate No. 1 - Exactly as given in print from Mr. Niederhoff.

Alternate No. 2 - Same as No. 1 except that 1 on 4 slope of 80' wide channel to El. 883 was replaced by a 1 on 8 slope to new channel floor at El. 878. The channel elevation of 878 was also held for Alternate No. 3 and No. 4.

Alternate No. 3 - The 122' side walls were reduced to a length of 90' and the end sill was moved toward the outlet portal to a distance of 90' from the end of the parabolic drop, otherwise identical to Alternate No. 2. In effect, Alternate No. 3 was a basin 90' long.

Alternate No. 4 - Same as Alternate No. 3, except that the single row of floor blocks was replaced by two rows of blocks.

Comparing Figure A-1 with Figure 4 of the basic report the outstanding revisions consist of the new conduit exit transition, and 80' rather than a 40' channel and substantially a doubling of length of both the chute and the pool. The cross-section of the pool differs little from that for the original design. Tailwater depths for the alternate design were governed by the data of Figure 28. A maximum conduit discharge of 13,000 c.f.s. was specified for testing by the sponsor.

The writers' were joined by Mr. C.W. Pickering of the sponsoring firm from September 15 to 20 and 22 to 27, 1952, periods covering the most important tests. Performance of Alternate No. 2 was observed by Mr. Niederhoff and Mr. Connelly on September 20, and on September 26, 1952 by Mr. Courtney. Alternate No. 3 was authorized in a letter from Mr. Niederhoff dated September 29, 1952. After Mr. Niederhoff and Mr. Pickering had witnessed the performance of Alternate No. 3 on October 10, 1952, testing of Alternate No. 4 was verbally authorized.

Alternate No. 4 was the most satisfactory in general; however, the other three arrangements could not be considered unsatisfactory. Each of the Alternate designs performed substantially better than either the "original" or "revised" design indicated in Figures 4, and 36 of the basic report. The criteria of acceptance were performance, economy and overall safety.

<u>All dimensions and values given in this report are in terms of prototype values.</u>

ALTERNATE NO. ONE

Description:

Since the details of the Alternate Design differed radically from those for the Revised Design, the latter was scrapped and a model of the Alternate Design constructed to a scale of 1:32. The transition from a circular to a rectangular section at the exit of the conduit was fabricated of clear plastic by Van Beek Industries of Orange, N.J. The transition was preceded by 10' of the lucite pipe used in the original tests (set at the new slope) and 10' of steel pipe, terminating in a funnel entrance and connected to an entrance tank. The gate chamber and entrance of the original model were not used since only the new exit transition and stilling basin were being investigated and the space necessary to accommodate the new conduit length (approximately 300 feet longer than that shown in basic report) was not available at the time in the laboratory. The wood tank housing the stilling basin was one and one-half times as long as the one used in the tests of the basic report. A sensitive tailgate was installed at the downstream end of this tank. A total of 38 piezometer taps were located in the exit transition and conduit.

Performance:

The first trial run on September 18, 1952 indicated that at higher discharges flow in the 80' channel was too unstable, being near the critical depth and therefore acting as a control, and the channel floor was lowered to El. 878 in accordance with the instructions given by the sponsor.

The necessity of utilizing floor blocks and chute blocks was investigated at 13,000 c.f.s. by removing both sets one at a time. Without the chute blocks the toe of the jump moved downstream and the jump became unstable. Without both chute and floor blocks the jump moved down to the end sill and out of the basin.

ALTERNATE NO. TWO

With the 80' channel rising to El. 878 on a 1 on 8 slope, but details otherwise identical to those given in the sponsor's drawing, observations were made at 2,000; 6,000; 8,000; 10,000; and 13,000 c.f.s. Pertinent photographs appear in Figures A-2 to A-8. Velocity measurements at 0.2 and 0.8 depth for 8,000 and 13,000 c.f.s. were taken at the 80' channel, beyond the sloping section, and at the end of the concrete for Alternates 2, 3 and 4. These velocity data converted to prototype equivalents are given in Figures A-24 to A-27.

The toe of the jump at 13,000 c.f.s. was located at the center of the chute blocks. The end of the jump roller was approximately 15' upstream from the end sill at 13,000 c.f.s. In the velocity profiles of Figure A-25 and A-27, at the points behind the curved end walls the current meter was oriented 45° from the axis of the basin. The efficiency of the stilling basin is indicated by the uniform distribution of velocity since the average velocity at a traverse station was taken as the mean of the velocities at 0.2 and 0.8 depth; this is reflected in the closeness to which the computed discharge matches the actual discharge. For Alternate No. 2 it was necessary to take the traverse at the change in grade of the channel (a point further back was available for Alternates No. 3 and 4); since this point was in a region of non-uniform flow, the traverse discharge of Figure A-24 for Alternate No. 2 is therefore not completely representative.

Two factors became evident as the result of these tests: (1) the toe of the jump should be moved further up the chute and (2) for reasons of economy the basin proper could possibly be shortened while maintaining efficient action in the stilling pool. To approach these objectives, Mr. Pickering installed an extension of the end sill. The limiting condition for a stable jump occurred when the pool <u>floor</u> was shortened to about 90' of the original 122'. Tests were made (not recorded here) for this condition with the same floor block arrangement used for Alternates No. 2 and 3 as well as that for Alternate No. 4. These trial tests indicated that the two objectives listed above should be obtainable with a shortened basin since the toe of the jump moved up to the top of the chute blocks and the jump roller terminated in the vicinity of the new arbitrary end sill, for both floor block arrangements.

ALTERNATE NO. THREE

In shortening the pool walls to 90', it was possible to lengthen the 80' model channel beyond the break in grade to an equivalent of about 45'. For this Alternate a fairly uniform channel velocity distribution is indicated in Figures A-24 and A-26. Pertinent photos appear in Figures A-9 to A-15.

For 13,000 c.f.s. in Figure A-25, it may be noted that little change over Alternate No. 2 occurred in the velocity distribution near the bottom, but high velocities were concentrated nearer the surface (condition reflected in high average velocity indicated by traverse computed discharge).

The toe of the jump was located further up the slope (toe covered chute blocks) than in Alternate No. 2 and flow conditions in the channel were as good if not better than those noted for Alternate No. 2.

Further reduction of pool length was not considered wise since a temporary upstream extension of the end sill was not effective in moving the toe of the jump further up the chute and the stability of the jump was unsatisfactory. It was therefore concluded that the pool length of 90' was the minimum.

ALTERNATE NO. FOUR

The use of two rows of floor blocks instead of a single row had resulted in lowered velocities near the floor at the end of the basin in the trials leading up to Alternate No. 3, by Mr. Pickering. Further, it was argued that safe performance of the basin would be more assured should erosion of the first floor-block row take place, since the second row (located downstream from original single row) should not be affected by erosion, and standing alone would provide performance similar to that given by Alternate No. 3.

The performance of this arrangement is shown in Figures A-16 to A-23. Figure A-23 was a special possible combination requested by the sponsor: tailwater equivalent to flow over the spillway of about 40,000 c.f.s. and a conduit flow of 13,000 c.f.s. or a flow in the downstream channel of about 50,000 c.f.s.

In this arrangement, there was more surface disturbance at the end of the basin but this disturbance did not continue to the channel as indicated in the photos and the data of Figures A-24 and A-26. More important, the velocities near the bottom (Figures A-25 and A-27) have been reduced, with a corresponding increase in velocity in the upper part of the cross-section.

Alternate No. 4 is preferred from the standpoint of overall performance, economy and safety.

CONDUIT EXIT TRANSITION

The location and identification system used for the 38 piezometer taps are given in Figure A-29. A photo of the exit transition is given in Figure A-30. Data, converted to prototype pressure heads at the various tap locations for four rates of flow, are given in Figure A-31. The figures shown are accurate to within plus or minus 0.5 feet, prototype equivalent, in terms of accuracy of reading.

As with the original exit, negative pressures are relieved by a rise of the hydraulic grade line with increase in discharge. The cross-sectional area goes from 201 square feet at the conduit to 205 square feet at the exit, with a maximum area (because of type of transition) about 20' from the exit. This increase of area through the transition has the effect of alleviating pressures through the transition. All negative pressures at 13,000 c.f.s. could be raised to zero by making the transition longer - a total length of at least 150'. This is neither necessary nor economical. The negative pressures indicated are neither large nor dangerous. However, care should be exercised in constructing the section just before the transition, and particularly the beginning of the transition, to assure good alignment.

According to the data the loss over equivalent pipe friction due to the transition is practically zero at 13,000 c.f.s.

SUMMARY - COMMENTS - ACKNOWLEDGEMENTS

Alternate No. 4 should be considered the most desirable for the following reasons:

(1) The toe of the jump is as far up the chute as practicable without deepening the basin.

(2) The length of the pool is about as short as it can be consistent with good performance.

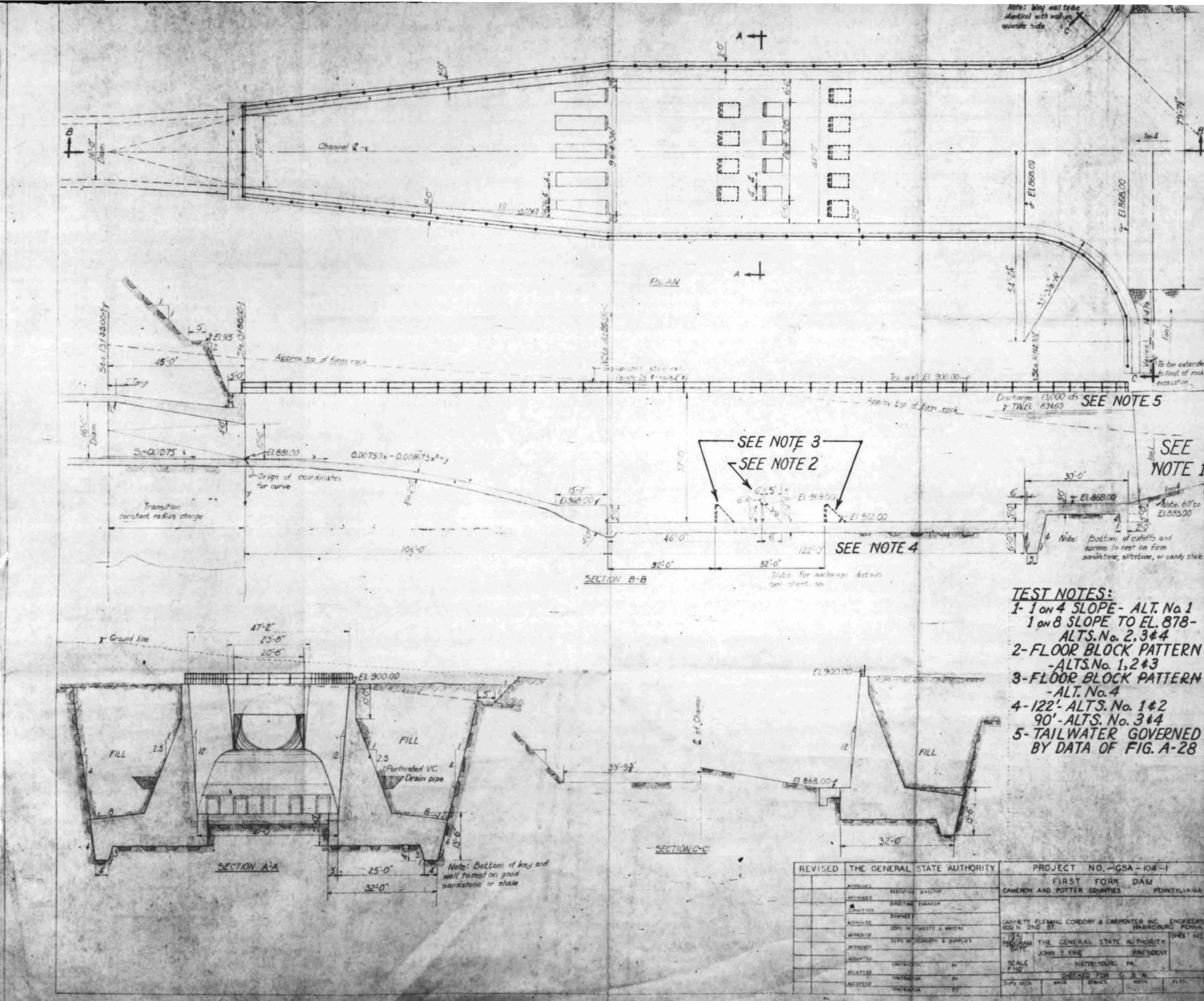
(3) The velocities near the bottom at the end of the concrete are as low or lower than those recorded for Alternate Nos. 2 and 3.

(4) The performance, in general, of this plan is equal to that for both Alternate No. 2 and No. 3.

A properly constructed exit transition should function without incident. In general, the distance over which negative pressures can exist are reduced as compared with the original plan with a continuous conduit.

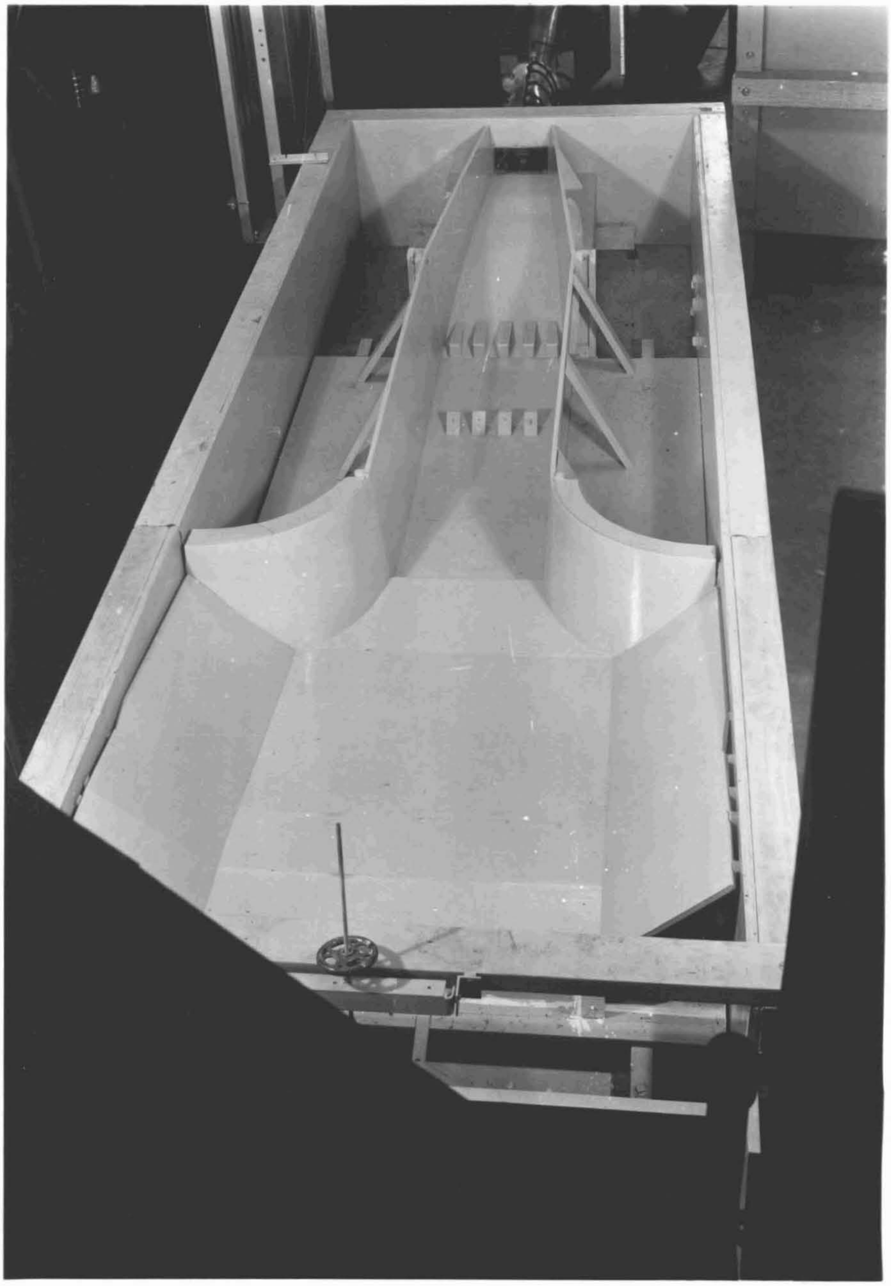
As pointed out by Mr. Pickering, it might be desirable that the chute walls start flush with the side walls of the transition exit, in the prototype, since this would avoid the separation of the jet from the walls noted in the model where the 1 on 12 slope was continued to the conduit transition exit.

The writers wish to express their appreciation to Mr. Pickering for his cooperation and assistance. Most of the credit for the changes made during the tests is due Mr. Pickering. This does not imply any transfer of the writers' responsibilities to him.



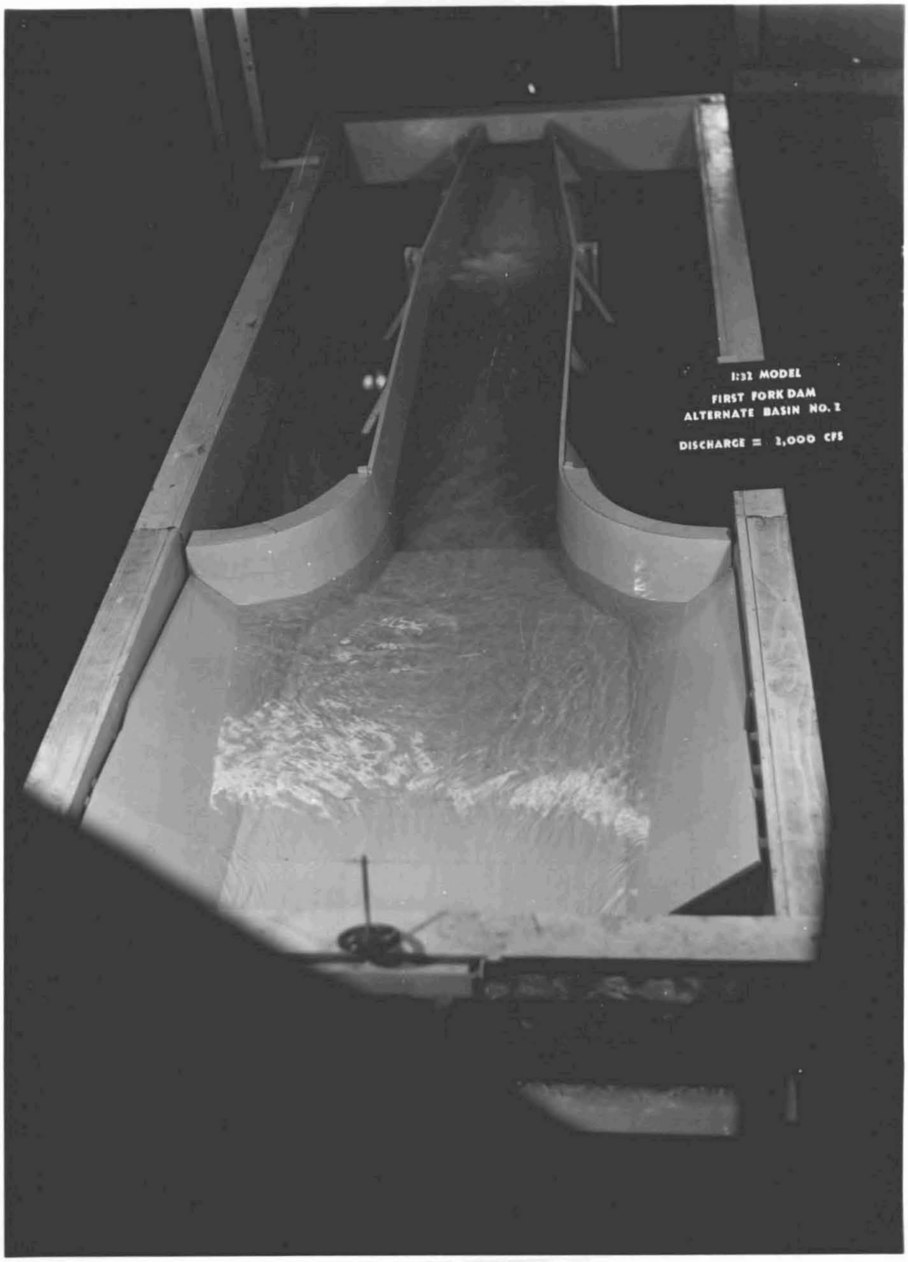
Note: Wing wall to be identical with wall on opposite side
PLAN
Channel ℄
SECTION B-B
Approx top of firm rock
Galvanized steel rail
Top wall El. 900.00
Discharge 13,000 cfs
TW.EL. 834.60
SEE NOTE 5
SEE NOTE 3
SEE NOTE 2
SEE NOTE 1
SEE NOTE 4
S=0.0075
El. 881.00
0.00750x - 0.001673x² = y
Origin of coordinates for curve
Transition constant radius change
El. 868.00
El. 863.00
106'-0"
46'-0"
122'-0"
32'-0"
30'-0"
To be extended to limit of rock excavation
Note: Bottom of cutoffs and aprons to rest on firm sandstone, siltstone, or sandy shale
TEST NOTES:
1- 1 on 4 SLOPE - ALT. No. 1
1 on 8 SLOPE TO EL. 878 - ALTS. No. 2, 3 & 4
2- FLOOR BLOCK PATTERN - ALTS. No. 1, 2 & 3
3- FLOOR BLOCK PATTERN - ALT. No. 4
4- 122' - ALTS. No. 1 & 2
90' - ALTS. No. 3 & 4
5- TAILWATER GOVERNED BY DATA OF FIG. A-28
Ground line
47'-2"
23'-8"
20'-6"
EL. 900.00
FILL
Perforated V.C. Drain pipe
SECTION A-A
25'-0"
32'-0"
Note: Bottom of key and wall to rest on good sandstone or shale
℄ of Channel
39'-9"
El. 868.00
SECTION C-C
REVISED
THE GENERAL STATE AUTHORITY
PROJECT NO. - GSA - 104 - 1
FIRST FORK DAM
CAMERON AND POTTER COUNTIES PENNSYLVANIA
GANNETT FLEMING CORDDRY & CARPENTER INC. ENGINEERS
600 N. 2ND ST. HARRISBURG PENNA.
THE GENERAL STATE AUTHORITY
JOHN S. FINE PRESIDENT
HARRISBURG, PA.
CHECKED FOR G.S.A.

FIGURE A-1

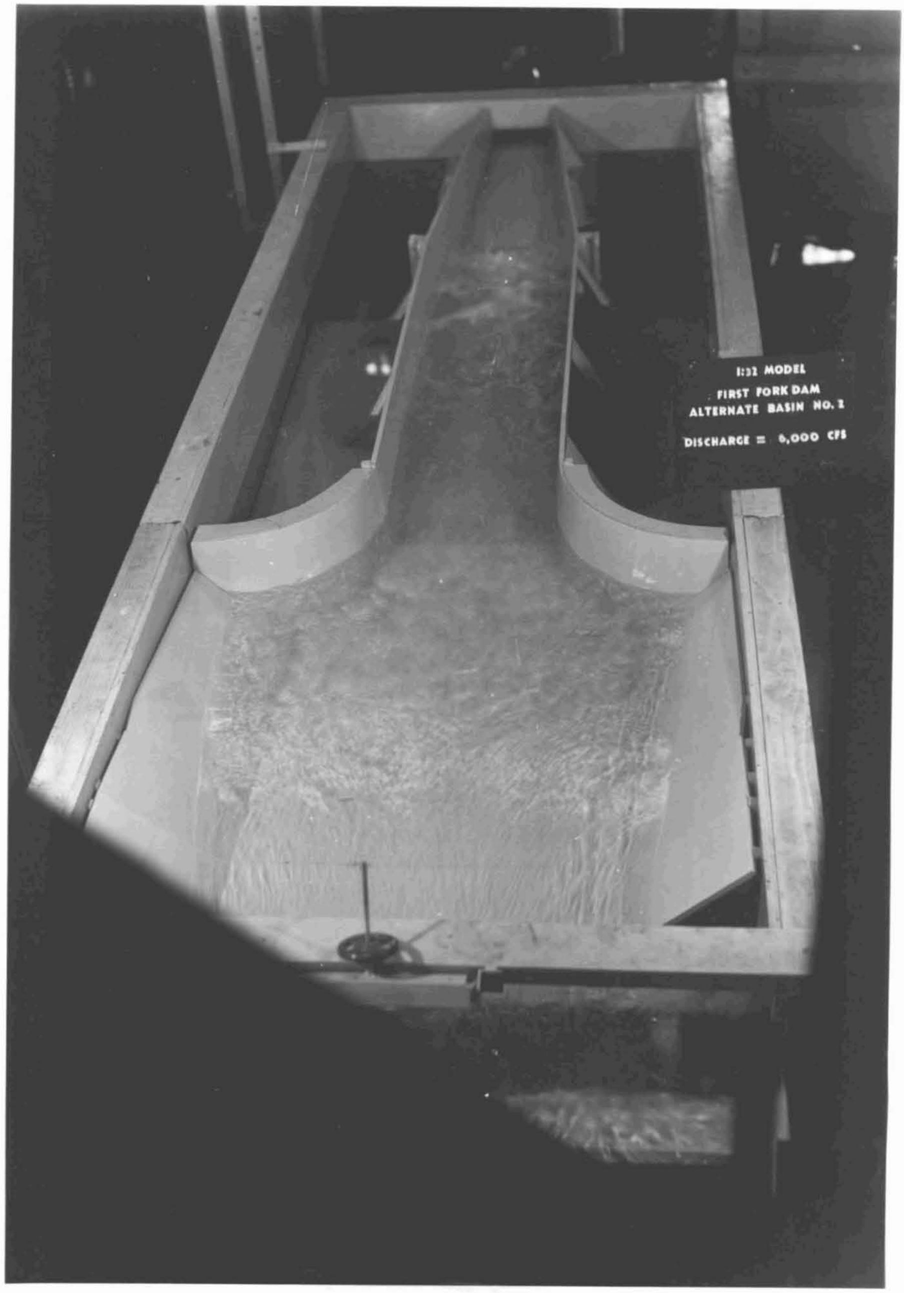


ALTERNATE NO. 2
DRY

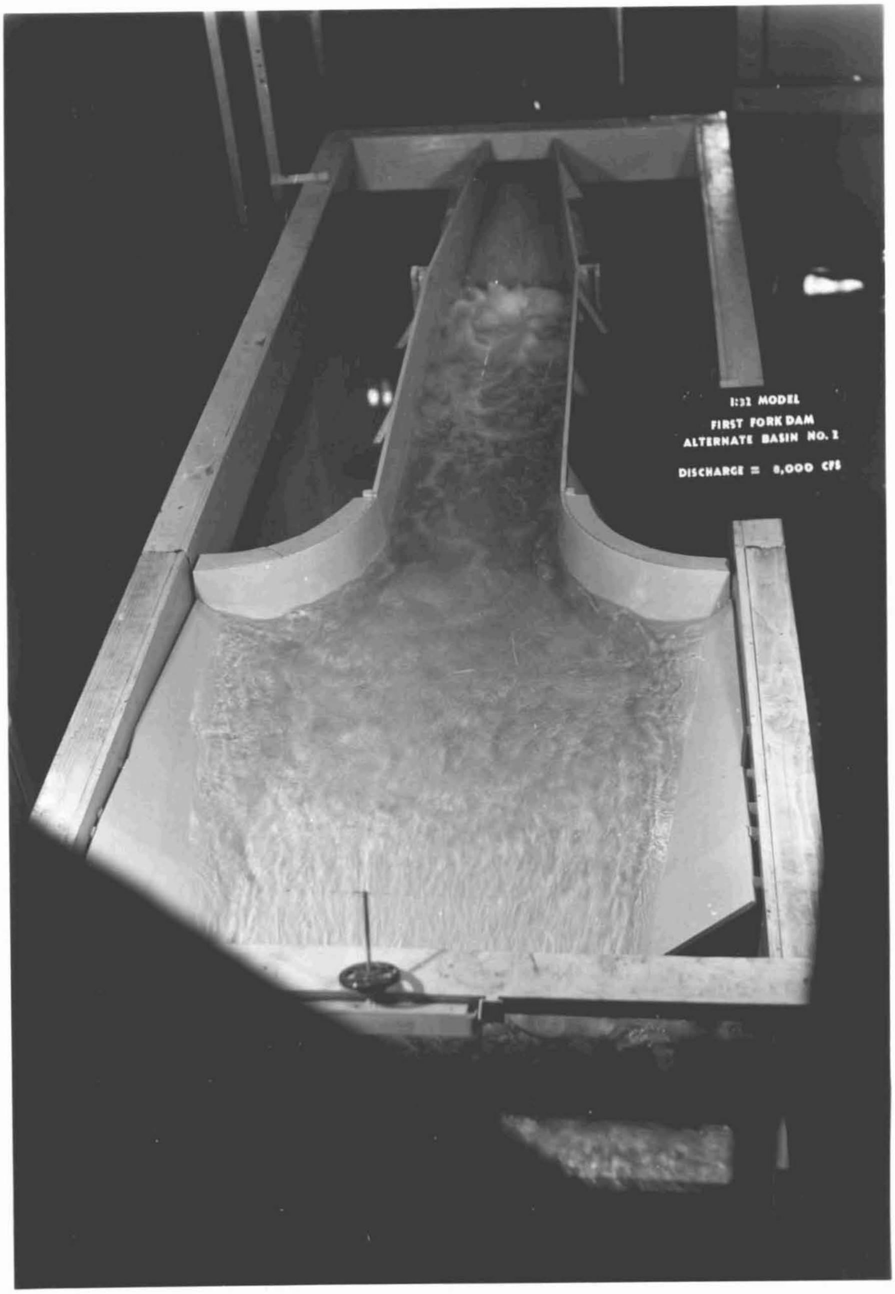
Figure A-3



ALTERNATE NO. 2
Discharge = 2000 cfs.

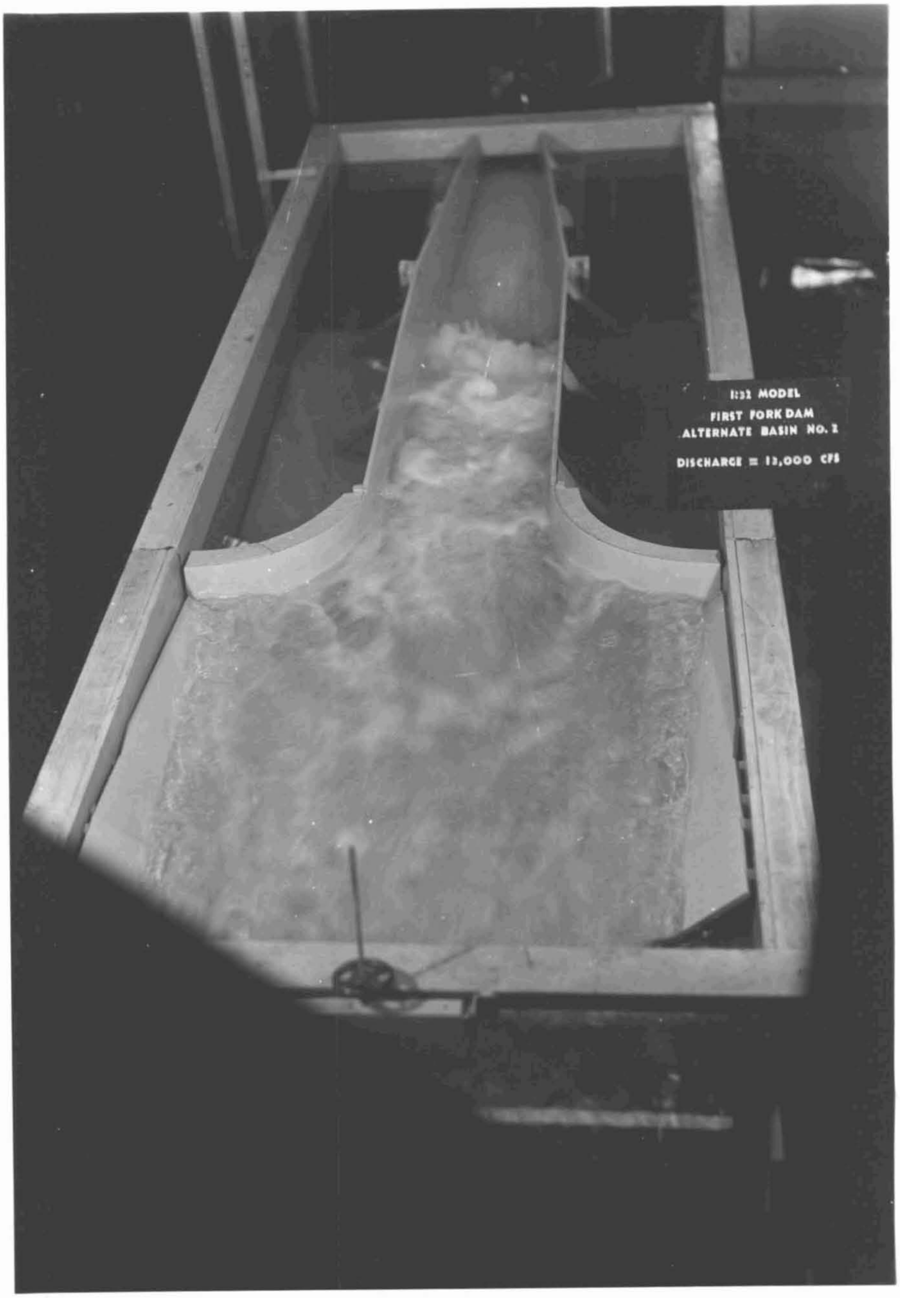


ALTERNATE NO. 2
Discharge - 6000 cfs.

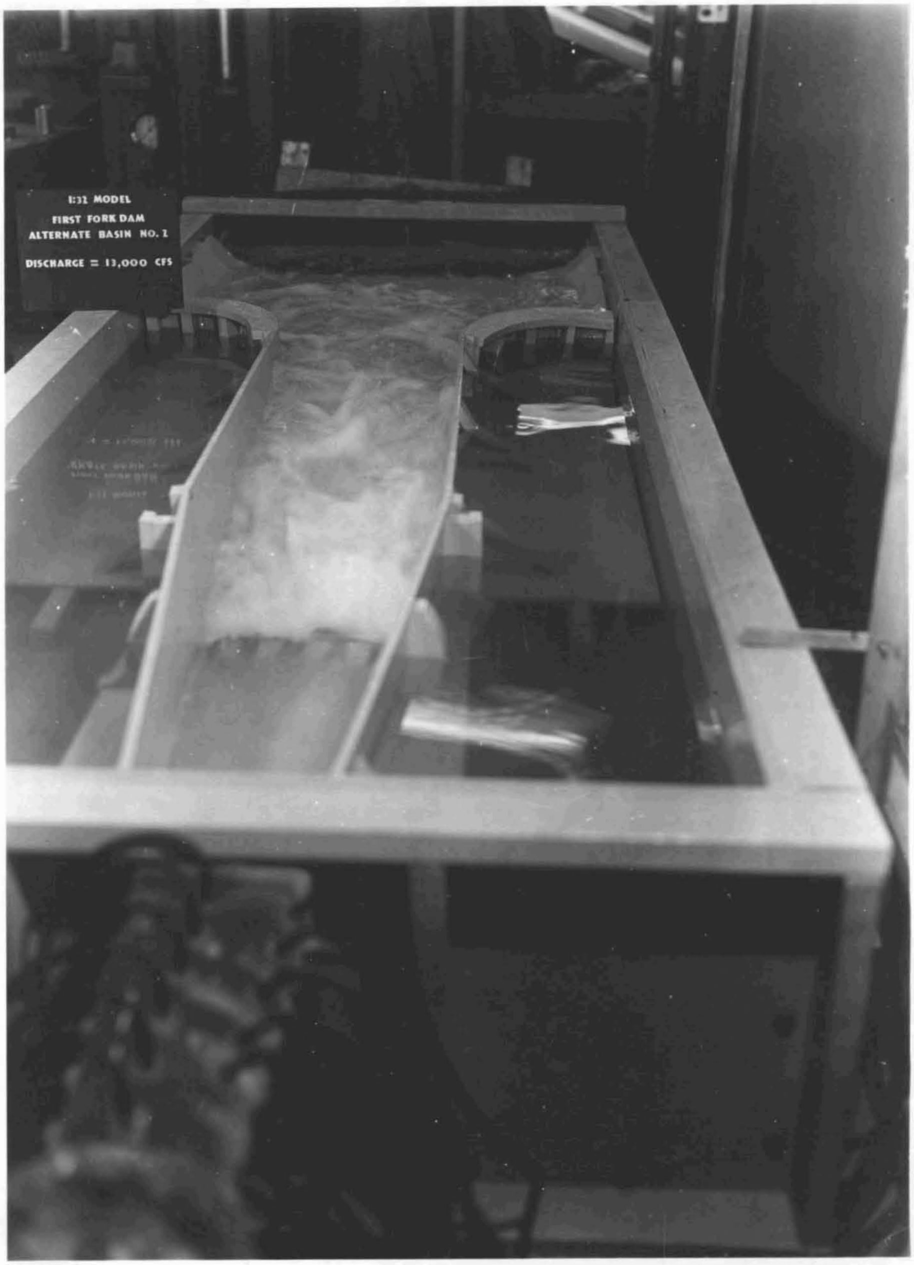


ALTERNATE NO. 2
Discharge - 8000 cfs.

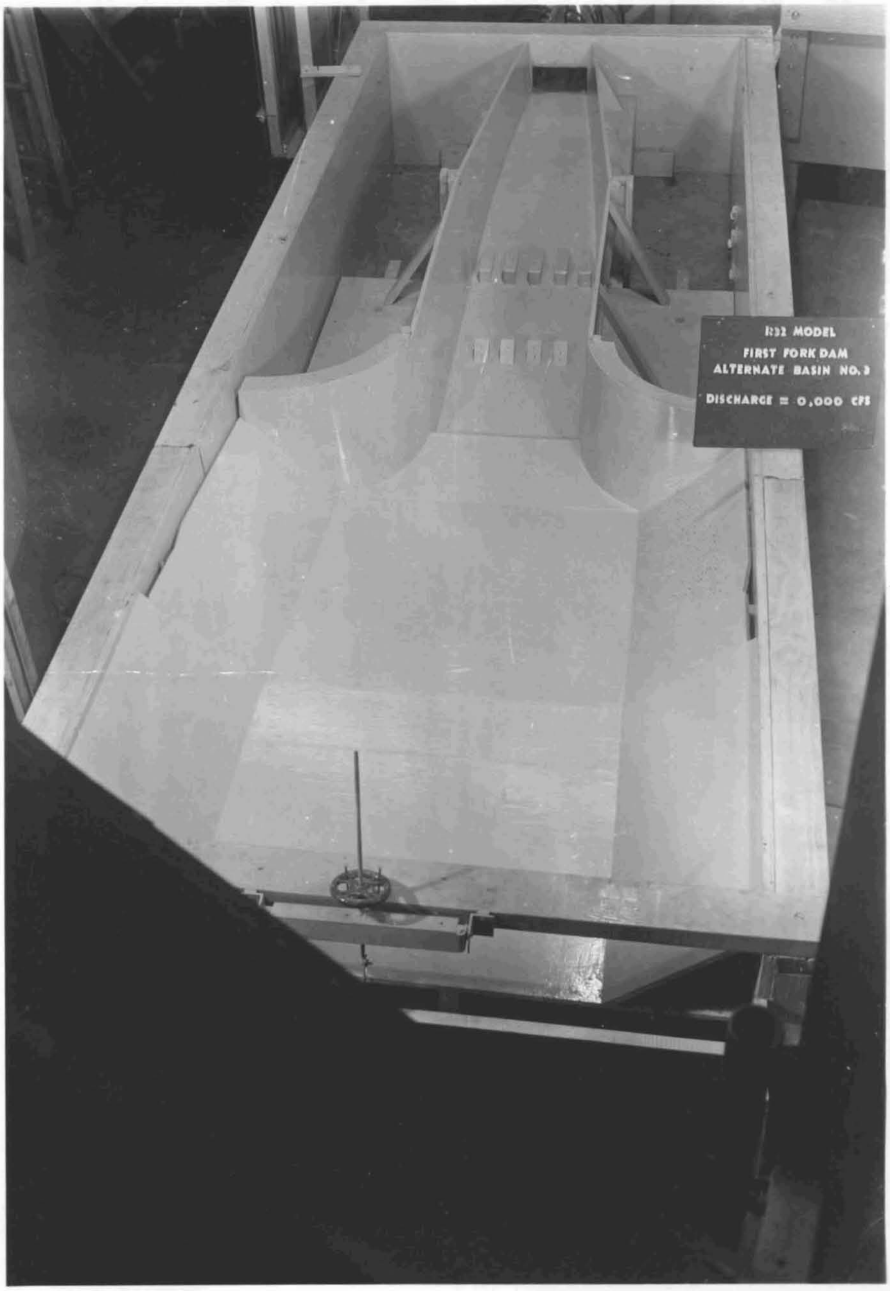
ALTERNATE NO. 2
Discharge - 10,000 cfs.



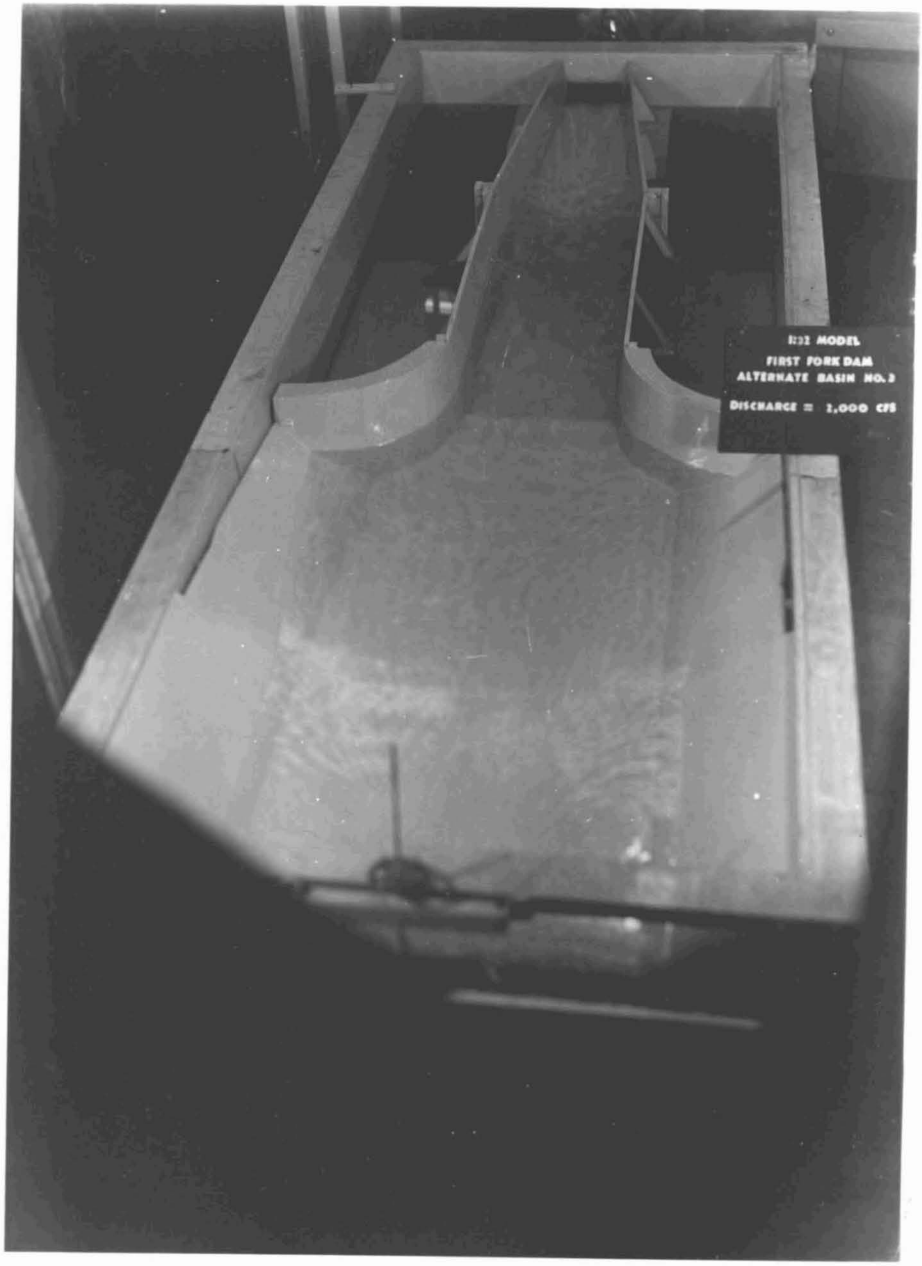
ALTERNATE NO. 2
Discharge - 13,000 cfs.
Looking upstream.



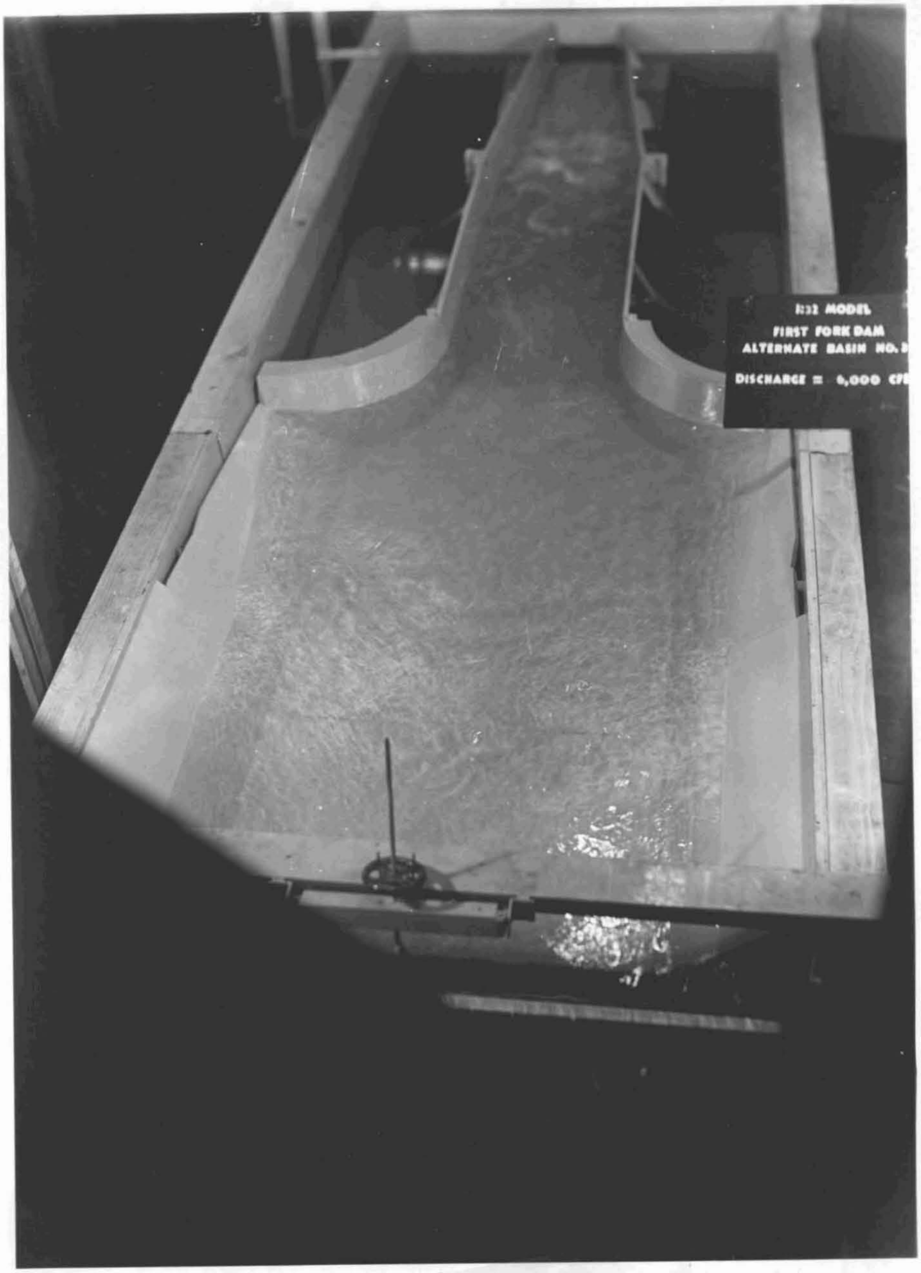
ALTERNATE NO. 2
Discharge - 13,000 cfs.
Looking downstream.



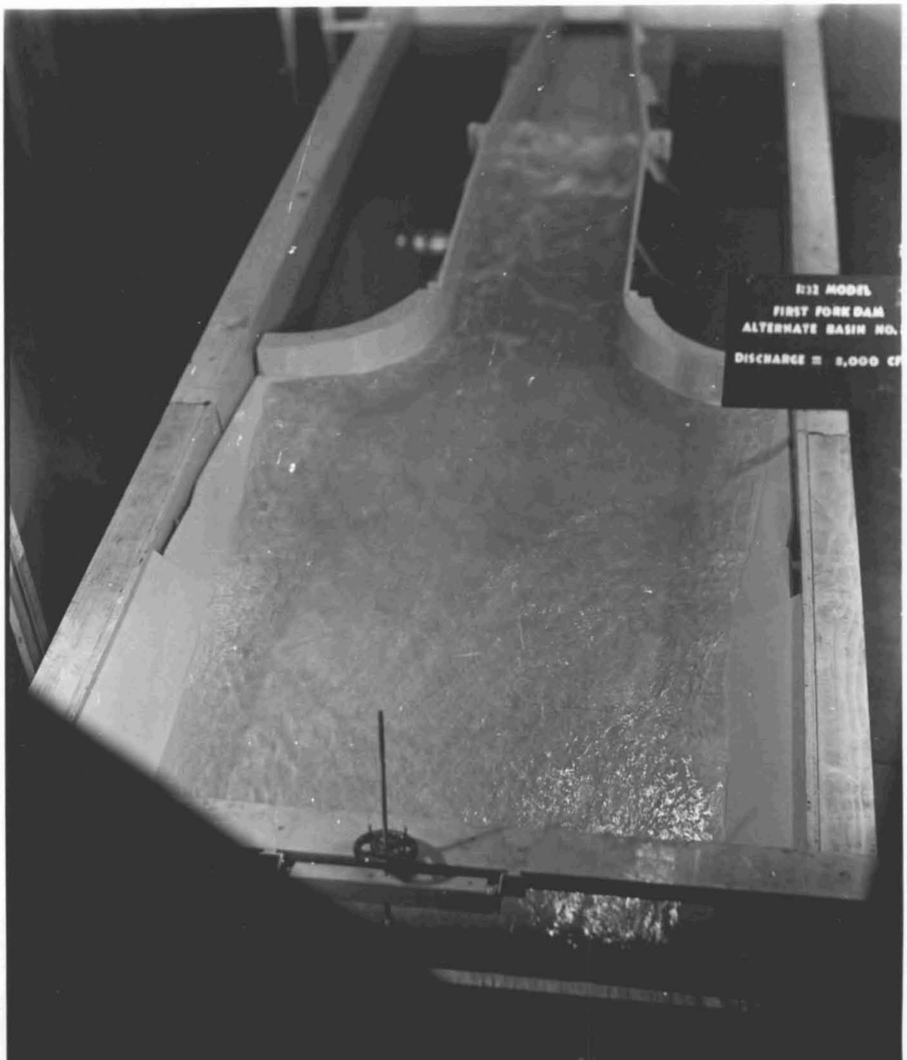
ALTERNATE NO. 3
DRY



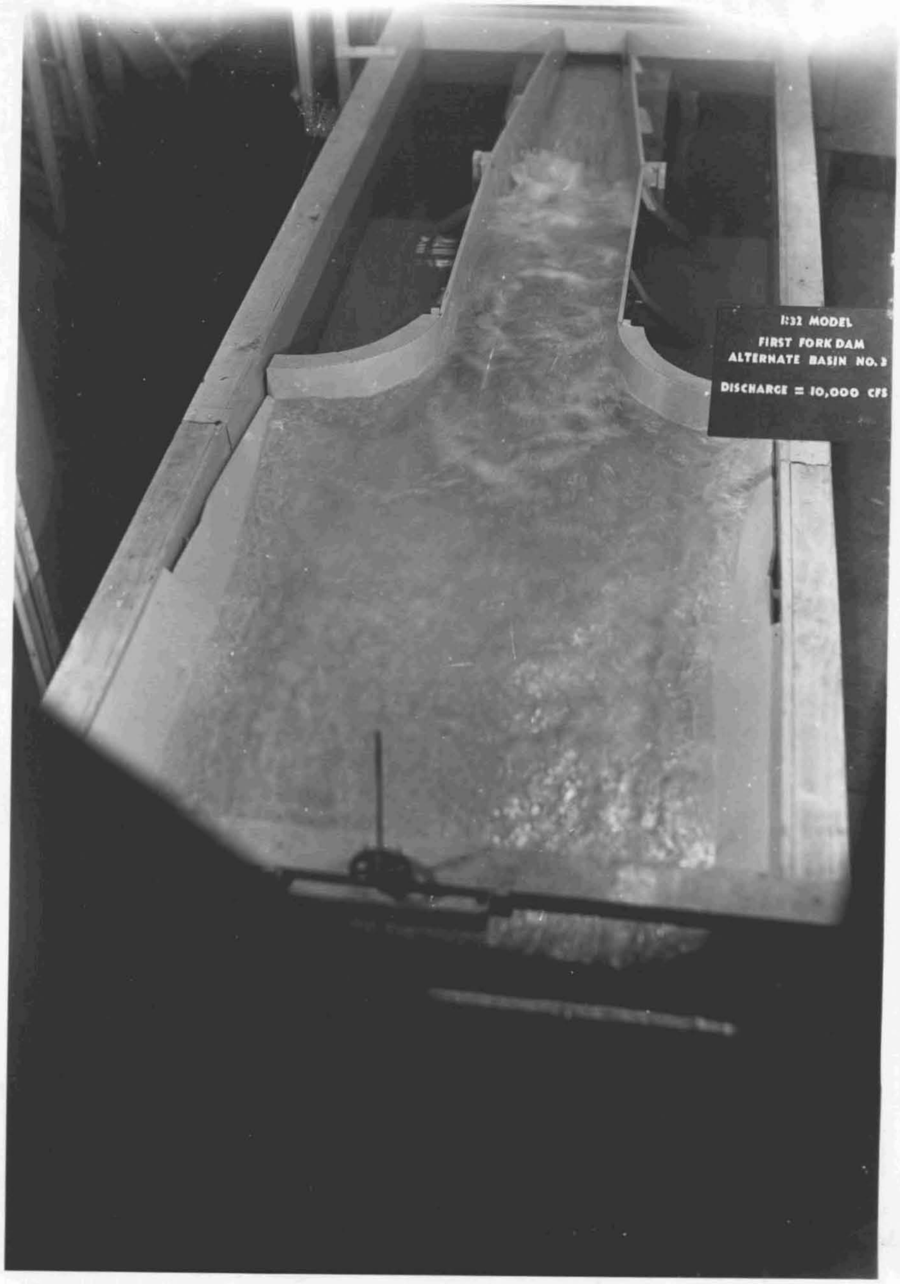
ALTERNATE NO. 3
Discharge - 2000 cfs.



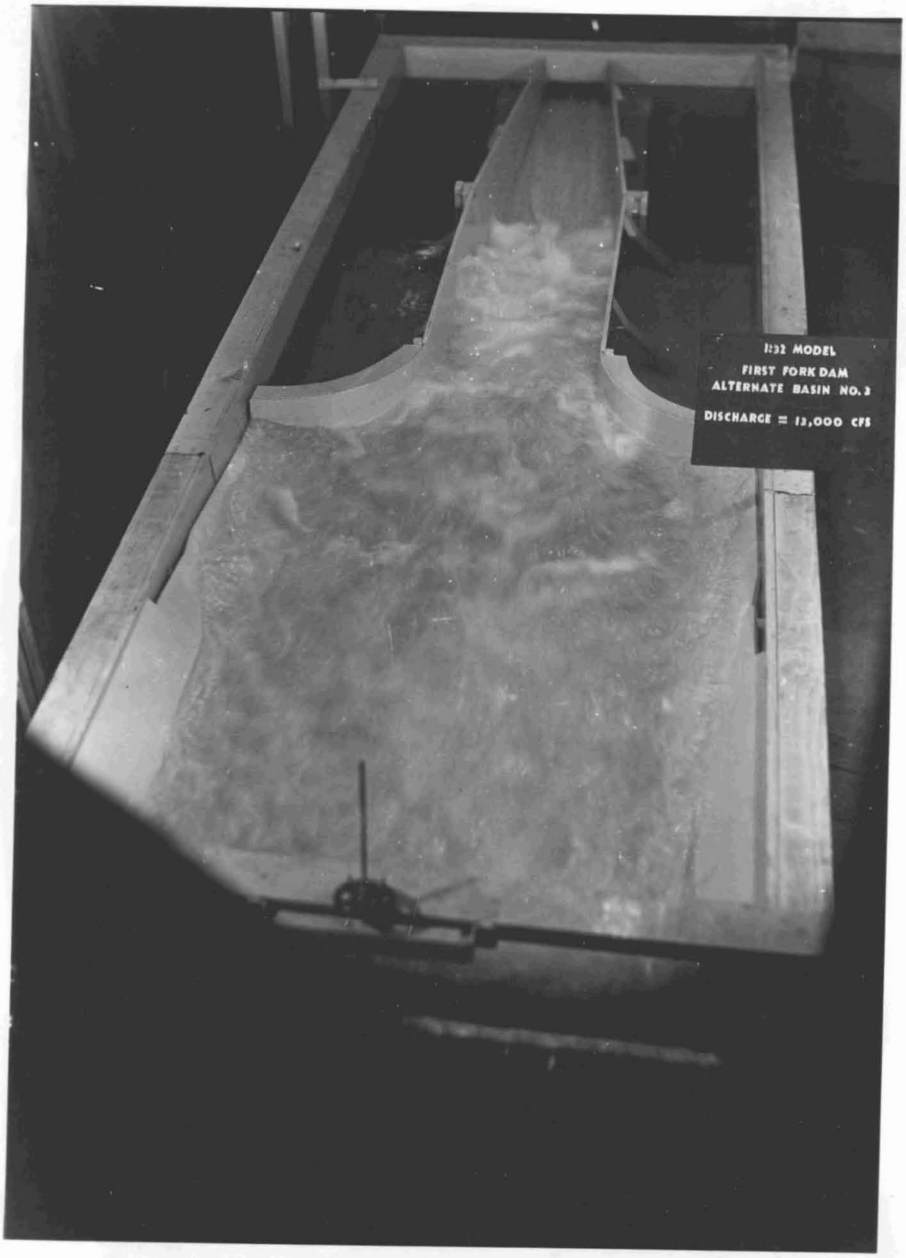
ALTERNATE NO. 3
Discharge - 6000 cfs.



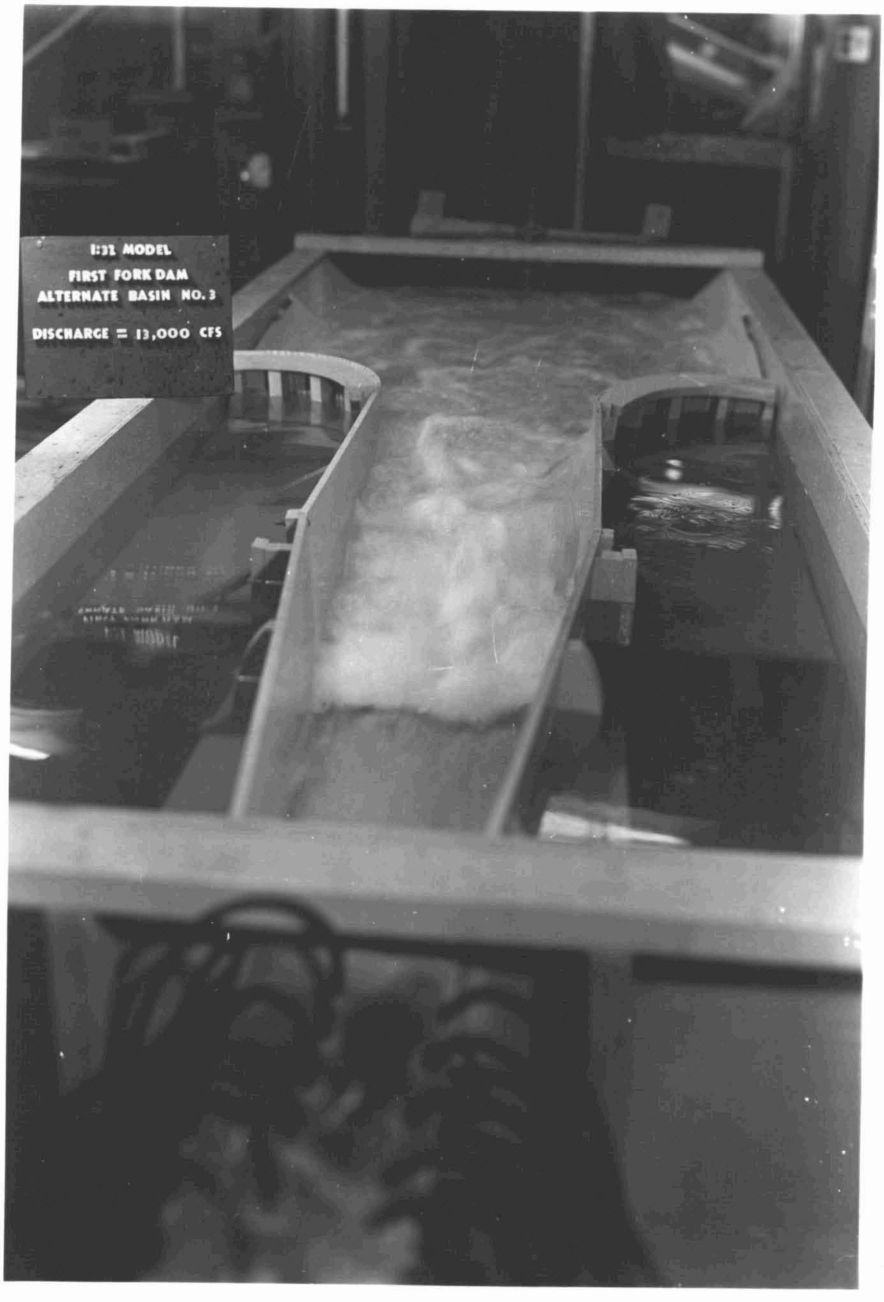
ALTERNATE NO. 3
Discharge - 8000 cfs.



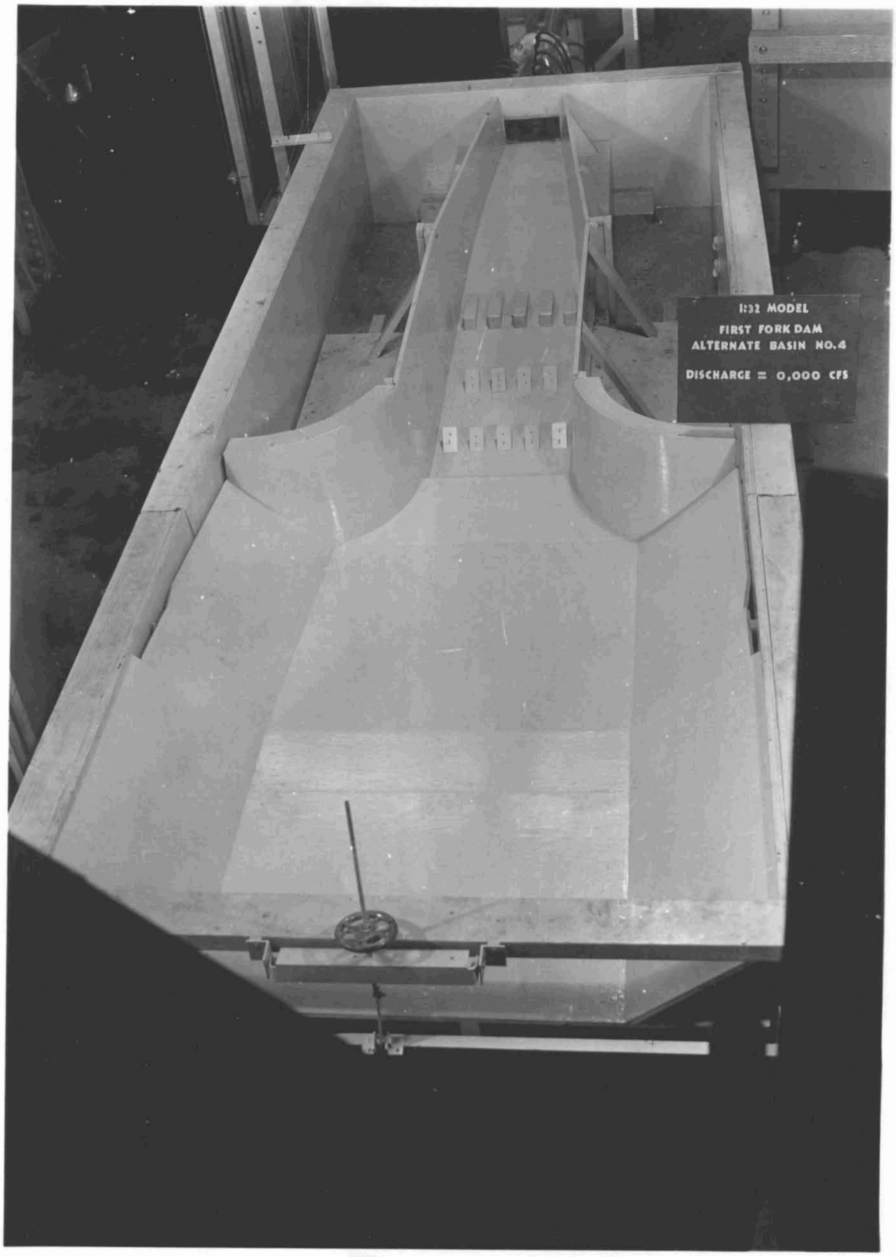
ALTERNATE NO. 3
Discharge - 10,000 cfs.



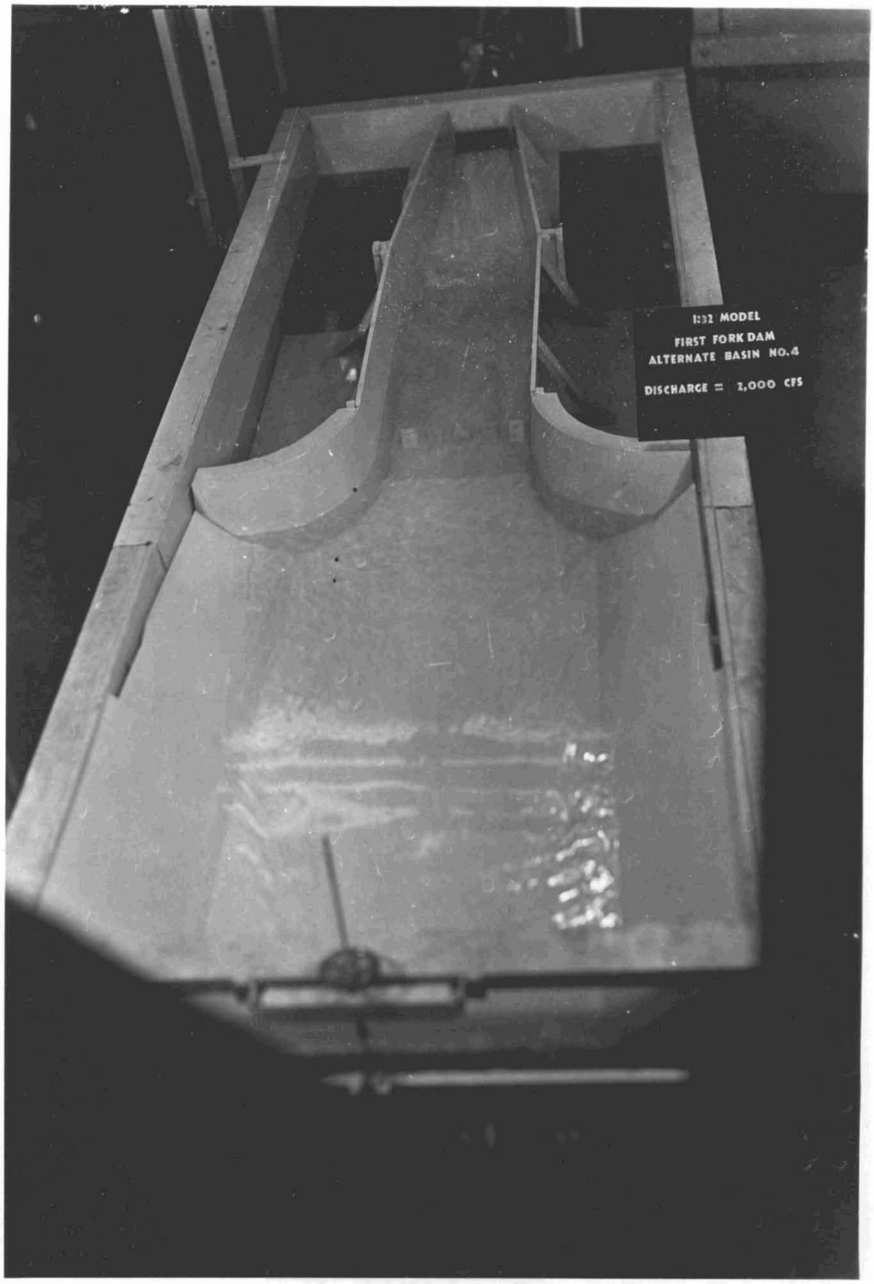
ALTERNATE NO. 3
Discharge - 13,000 cfs.
Looking upstream.



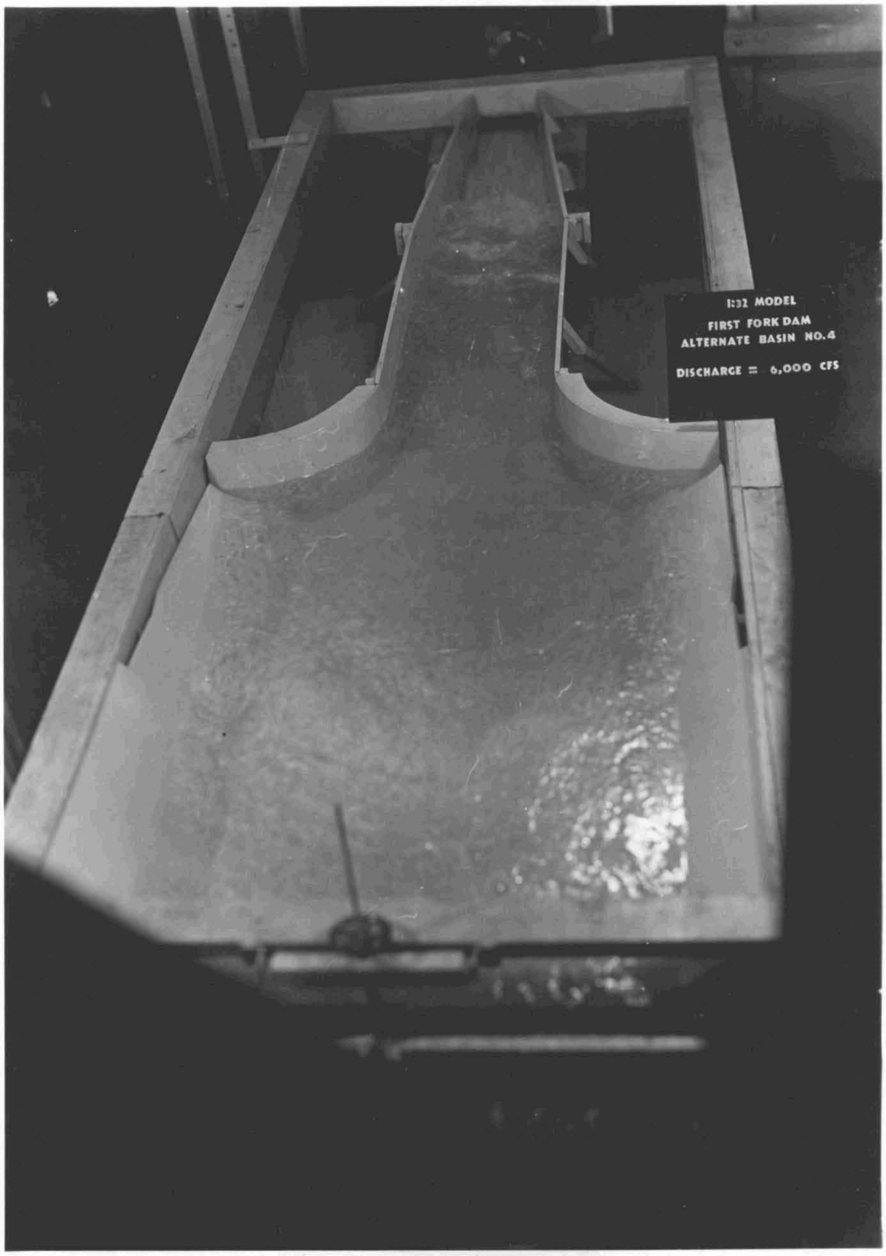
ALTERNATE NO. 3
Discharge - 13,000 cfs.
Looking downstream.



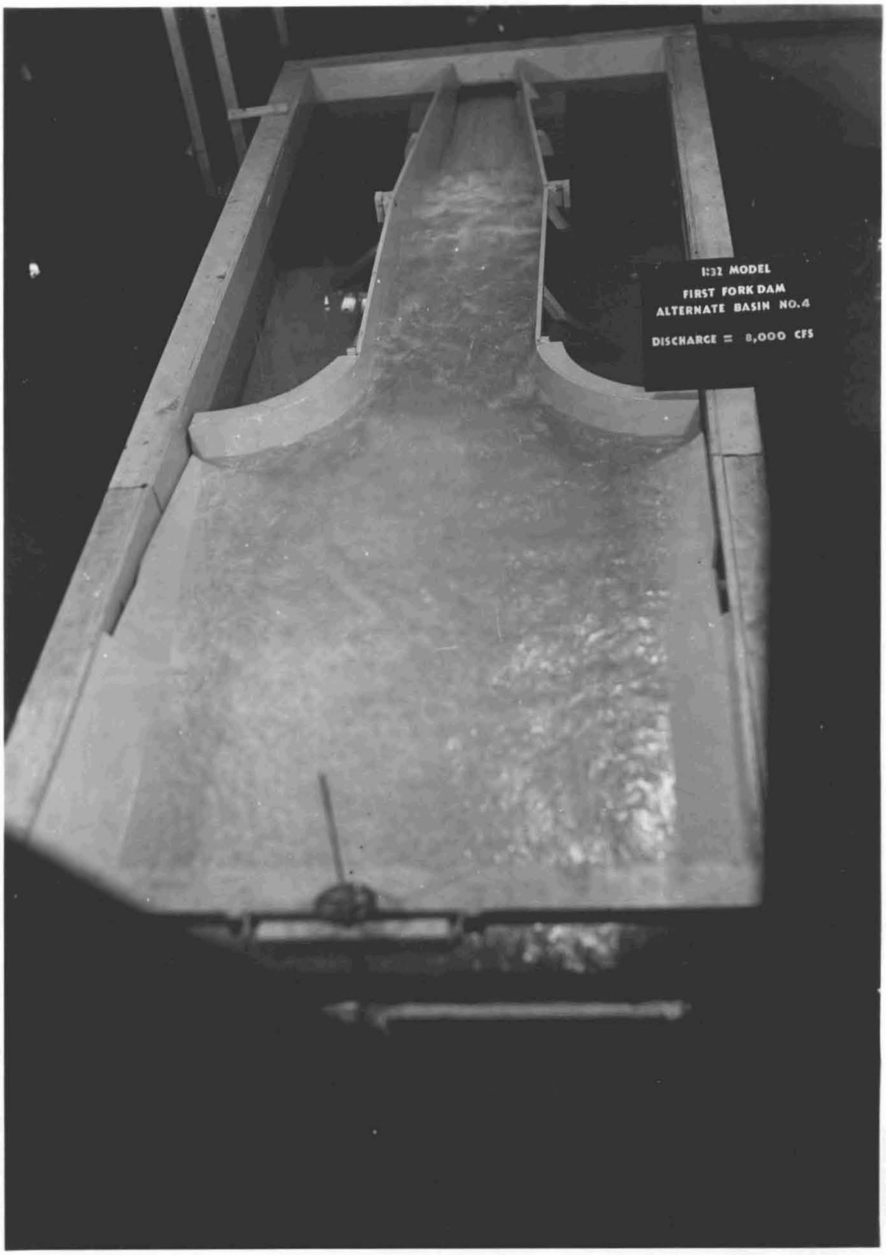
ALTERNATE NO. 4
DRY



ALTERNATE NO. 4
Discharge - 2000 cfs.



ALTERNATE NO. 4
Discharge = 6000 cfs.



ALTERNATE NO. 4
Discharge - 8000 cfs.

ALTERNATE NO. 4
Discharge - 10,000 cfs.

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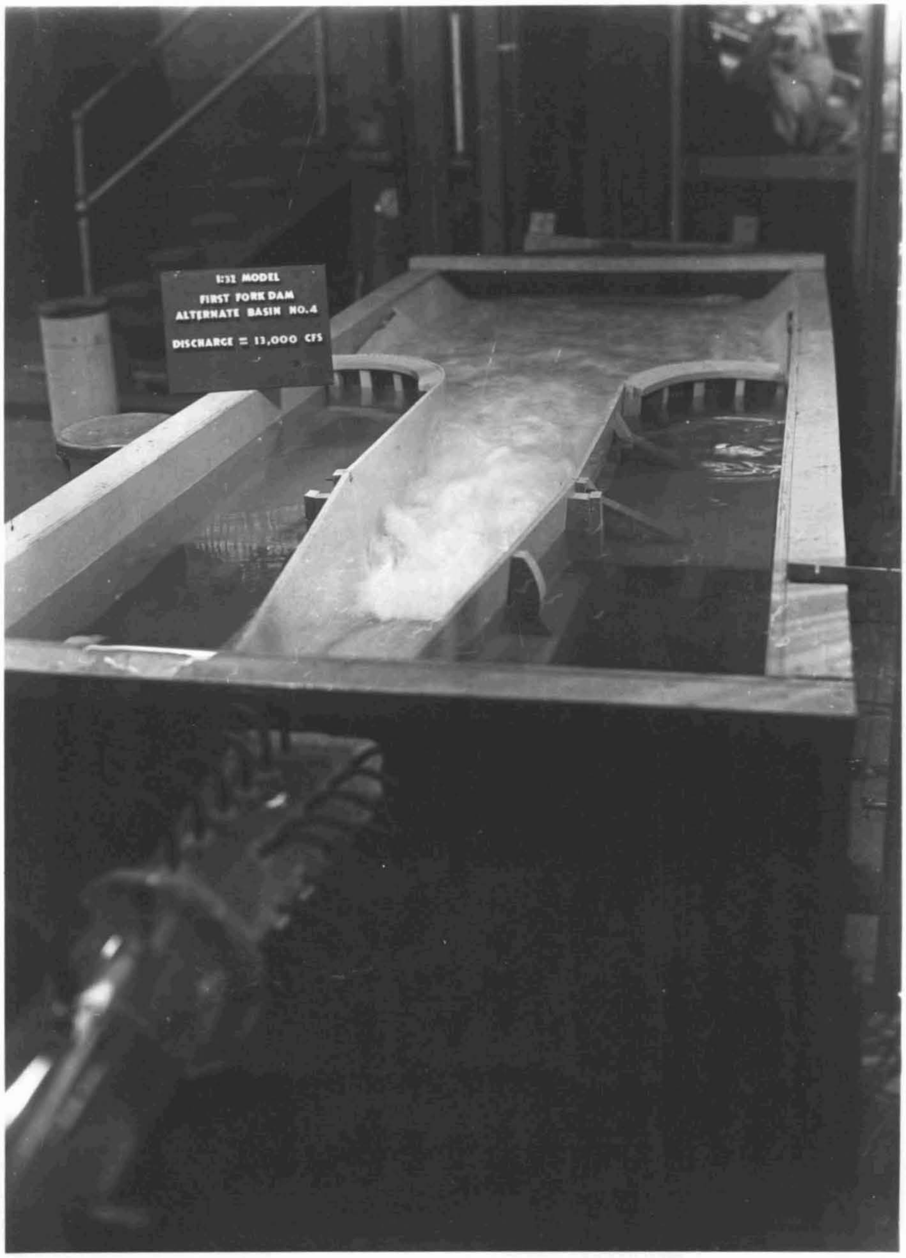
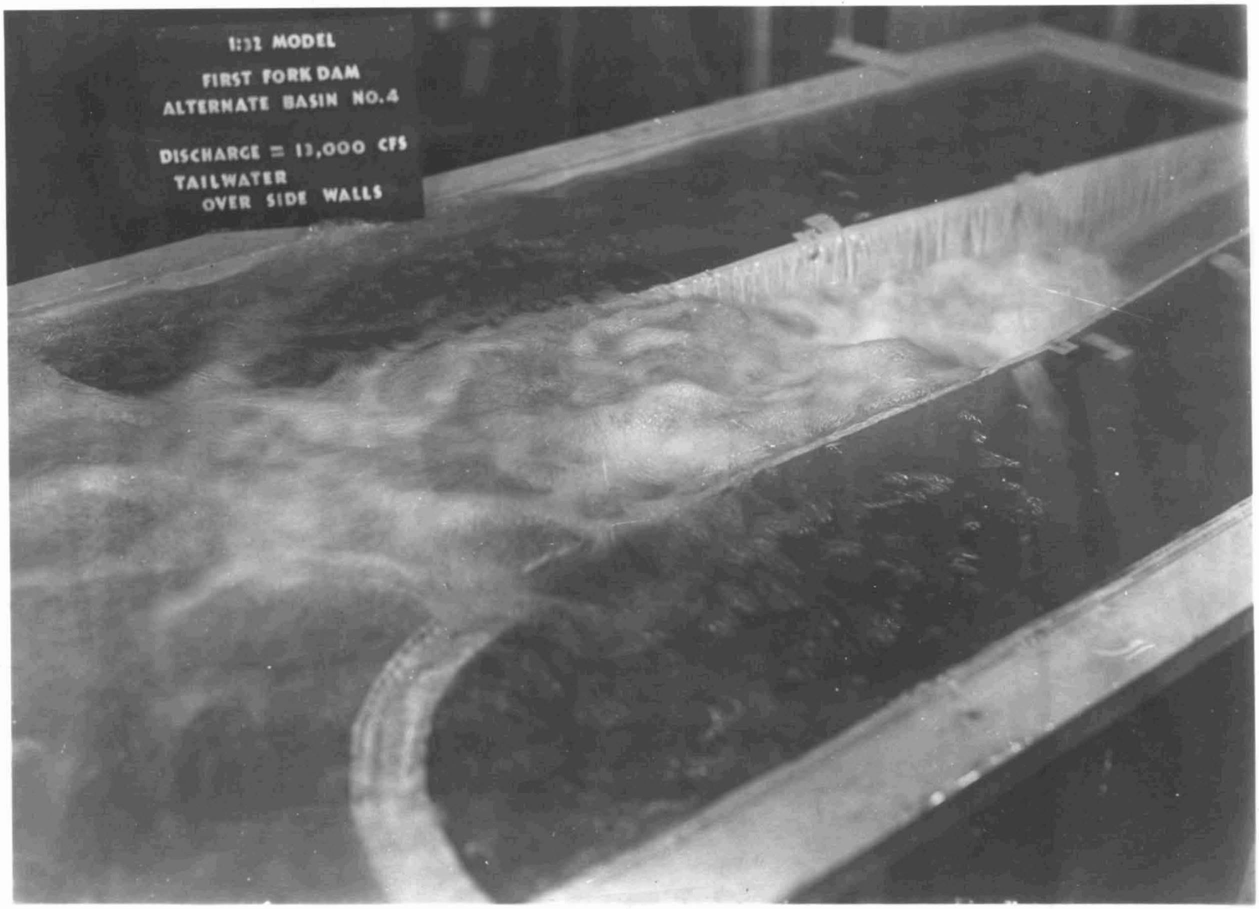
Figure A-21

ALTERNATE NO. 4
Discharge - 13,000 cfs.
Looking upstream.

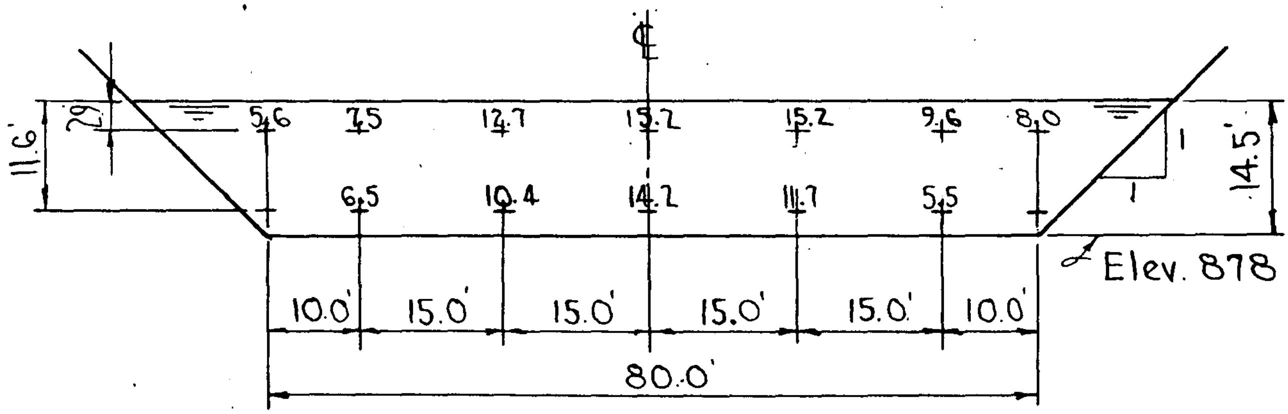


ALTERNATE NO. 4
Discharge - 13,000 cfs.
Looking downstream.

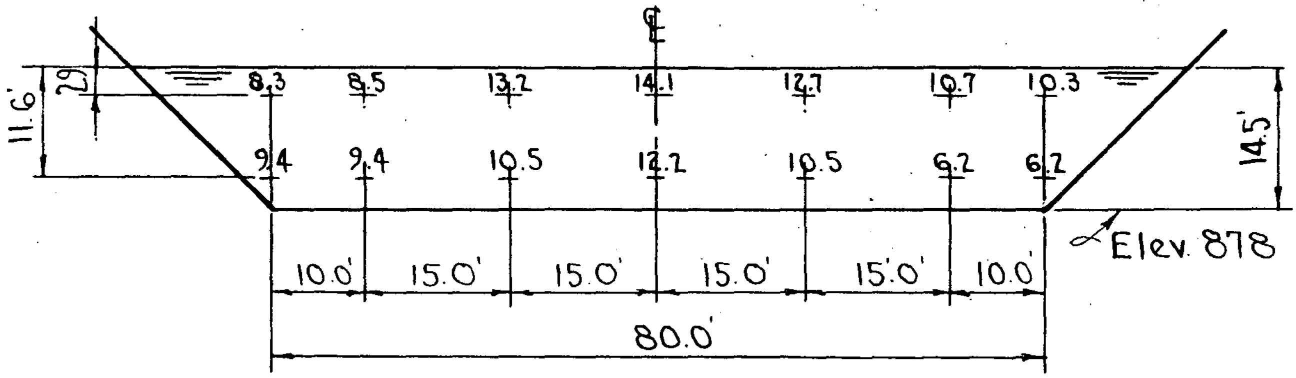


ALTERNATE NO. 4
Discharge - 13,000 cfs.
Tailwater Above Elevation 900.

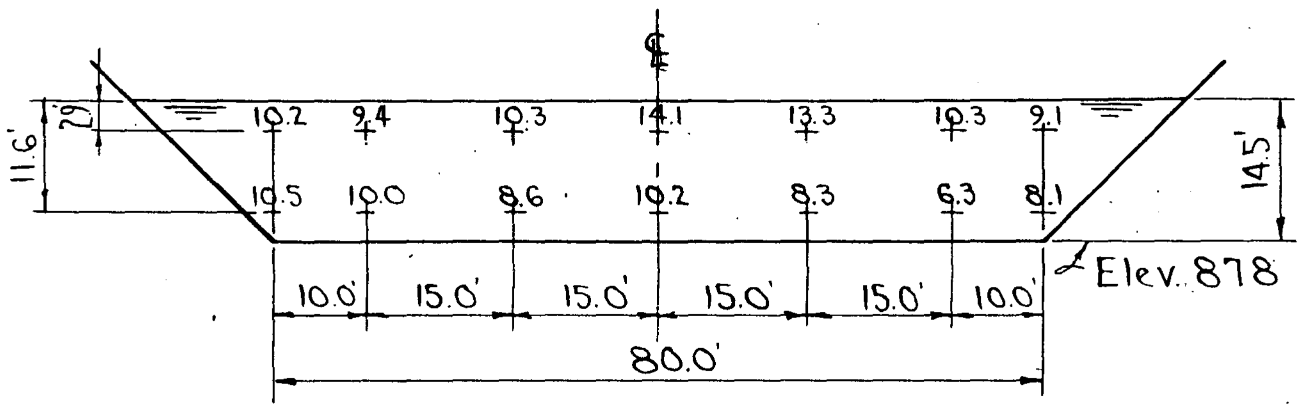
VELOCITY (PROTOTYPE) PROFILES 80 FOOT CHANNEL
13,000 CFS



Alternate No. 2 - At Sta 18+18 - (break in grade)
Discharge by traverse = 14,200 c.f.s.



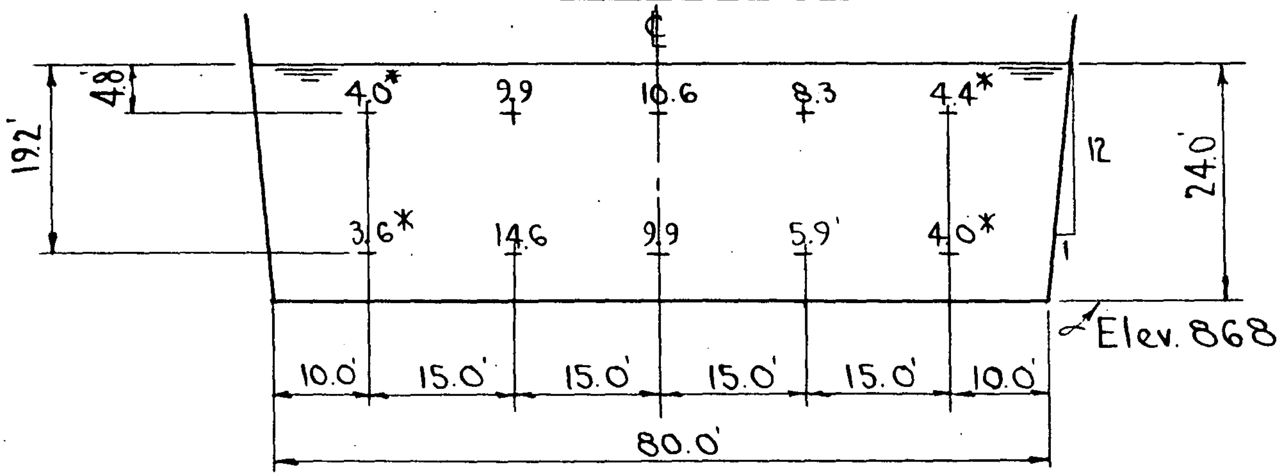
Alternate No. 3 - At Sta. 18+21 - (35' beyond break in grade)
Discharge by traverse = 13,300 c.f.s.



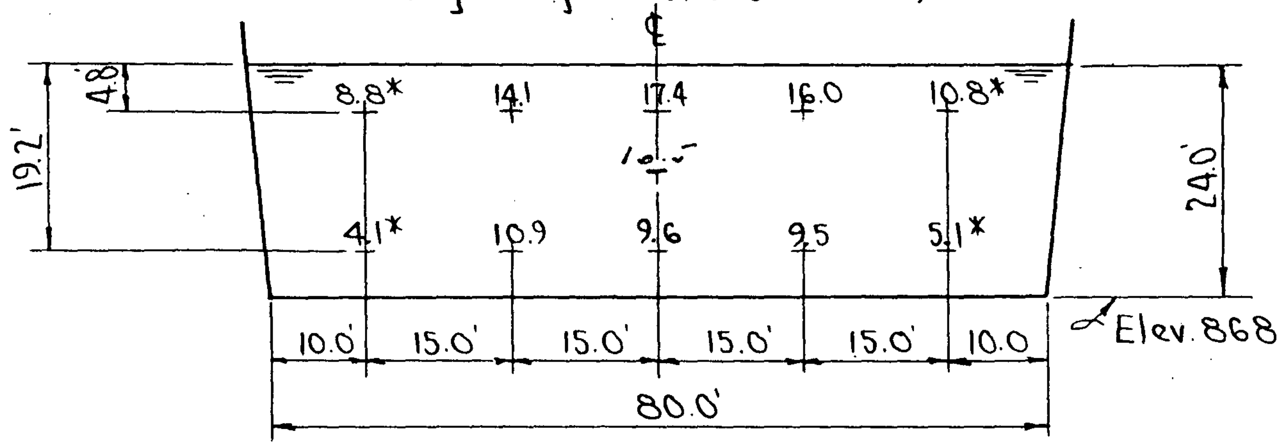
Alternate No. 4 - At Sta. 18+21 (35' beyond break in grade)
Discharge by traverse = 12,700 c.f.s.

FIGURE A-25

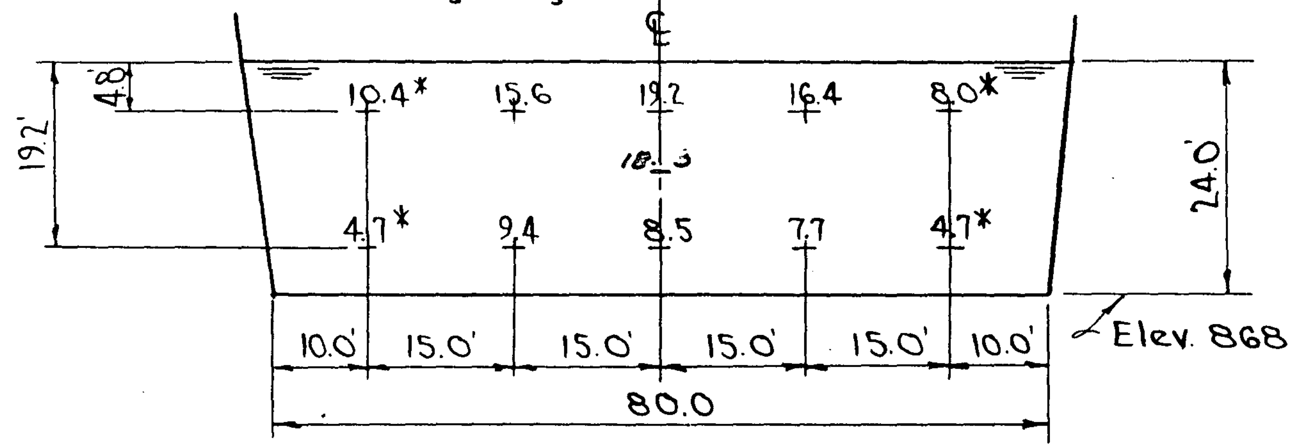
VELOCITY (PROTOTYPE) PROFILES END OF CONCRETE
13,000 CFS



Alternate No. 2 - At Sta. 16+38 (End of Concrete)
Discharge by traverse ≅ 13,900 c.f.s.



Alternate No. 3 - At Sta. 16+06 (End of Concrete)
Discharge by traverse ≅ 19,400 c.f.s.

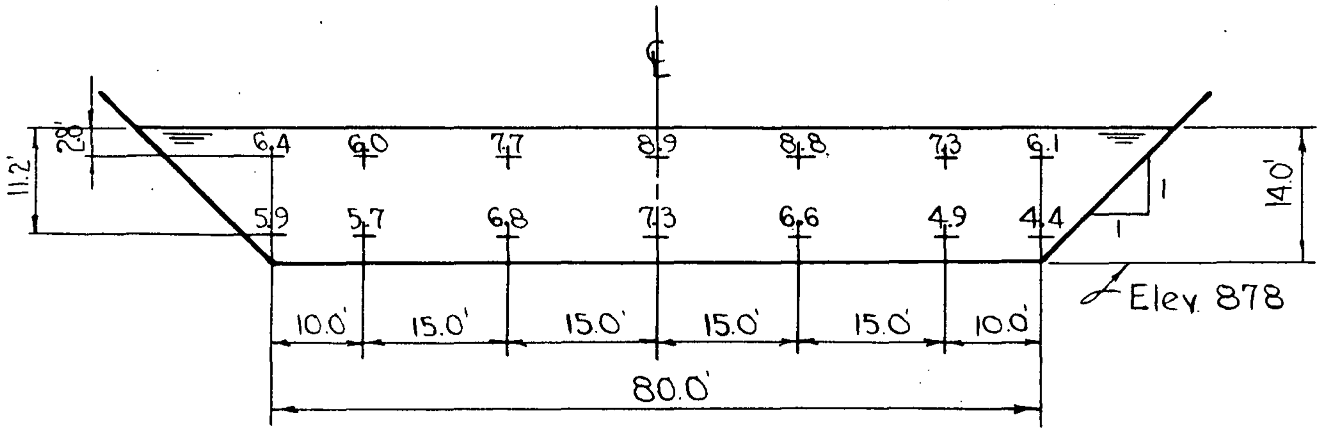


Alternate No. 4 - At Sta. 16+06 (End of Concrete)
Discharge by traverse ≅ 18,000 c.f.s.

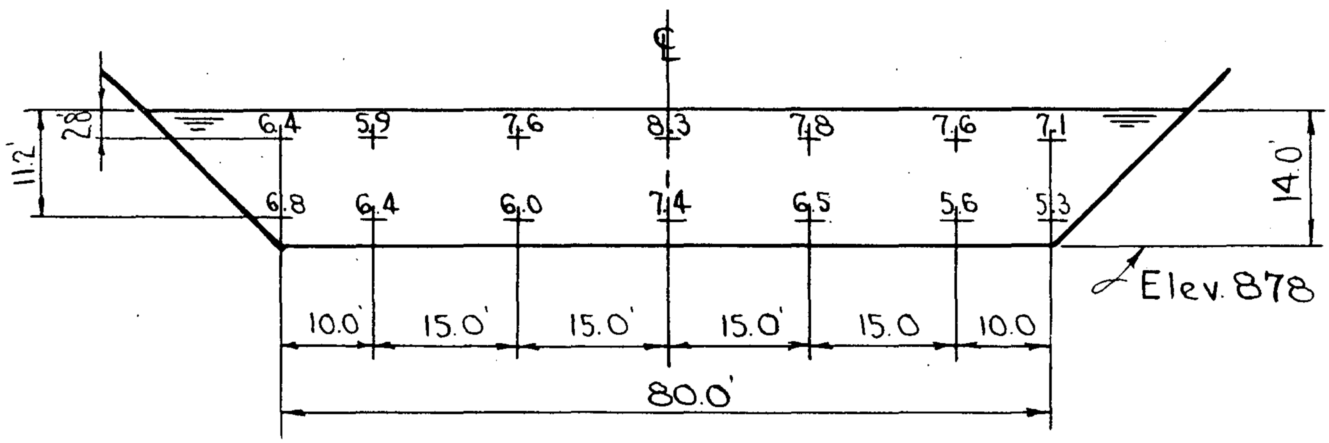
* Note - at 45° to axis of basin - behind curved walls.

FIGURE A-26

VELOCITY (PROTOTYPE) PROFILES 80 FOOT CHANNEL
8,000 CFS



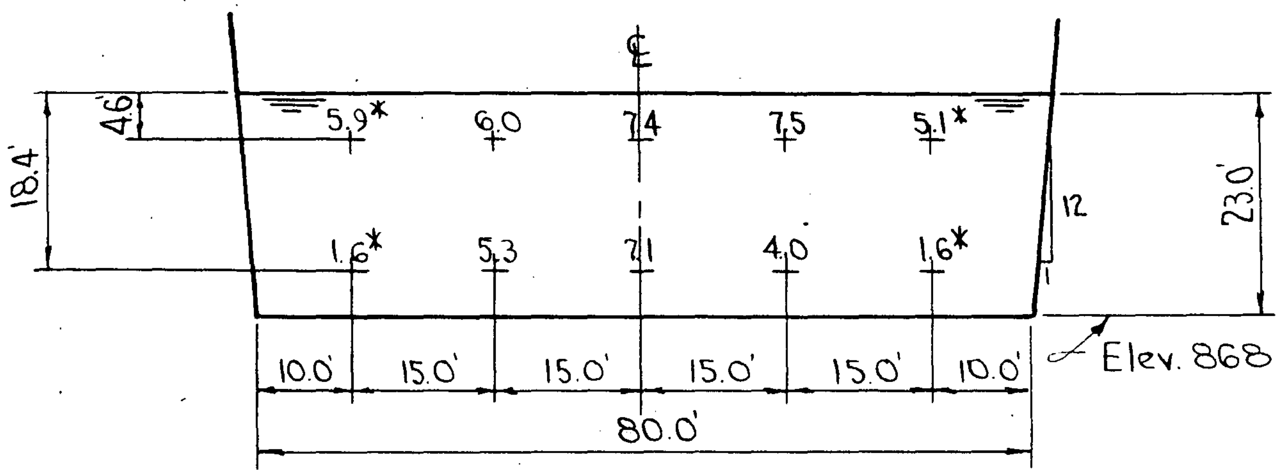
Alternate No. 3 - At Sta. 18+21 - (35' beyond break in grade)
Discharge by traverse = 8,300 c.f.s.



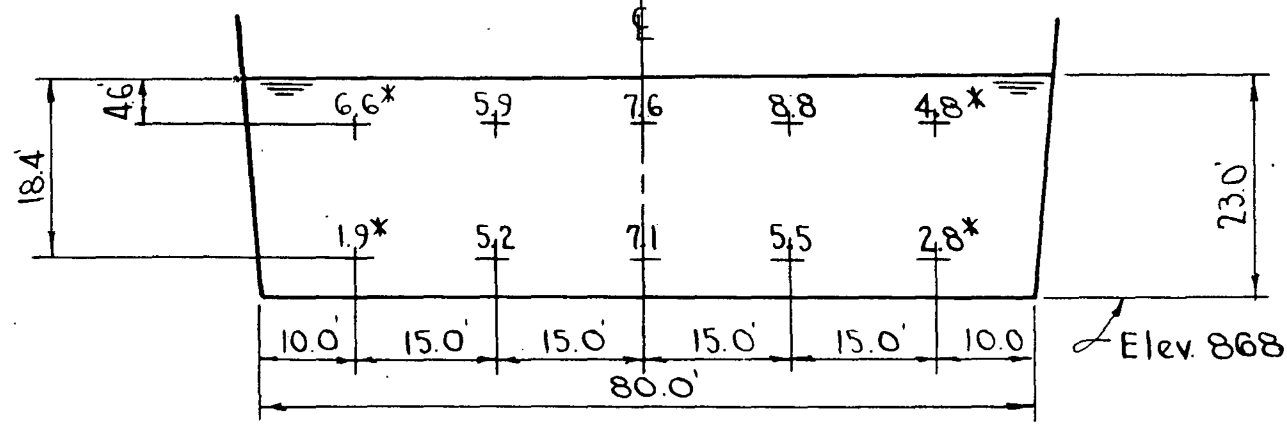
Alternate No. 4 - At Sta. 18+21 - (35' beyond break in grade)
Discharge by traverse = 8,300 c.f.s.

FIGURE A-27

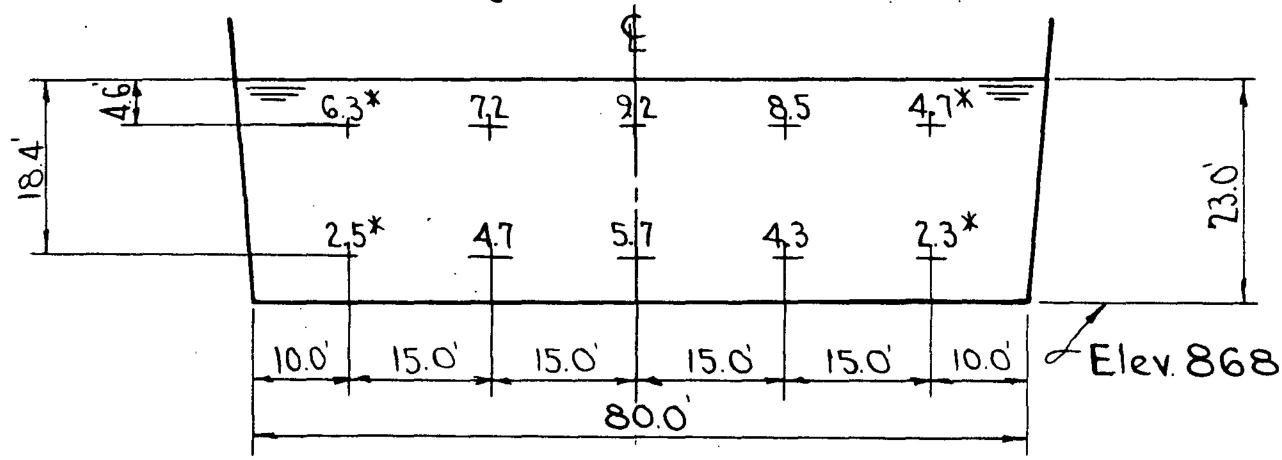
VELOCITY (PROTOTYPE) PROFILES END OF CONCRETE
8,000 CFS



Alternate No. 2 - At Sta. 16+38 (End of Concrete)
Discharge by traverse ≅ 8,500 c.f.s.



Alternate No. 3 - At Sta. 16+06 (End of Concrete)
Discharge by traverse ≅ 9,200 c.f.s.



Alternate No. 4 - At Sta. 16+06 (End of Concrete)
Discharge by traverse ≅ 9,100 c.f.s.

* Note - At 45° to axis of basin - behind curved walls

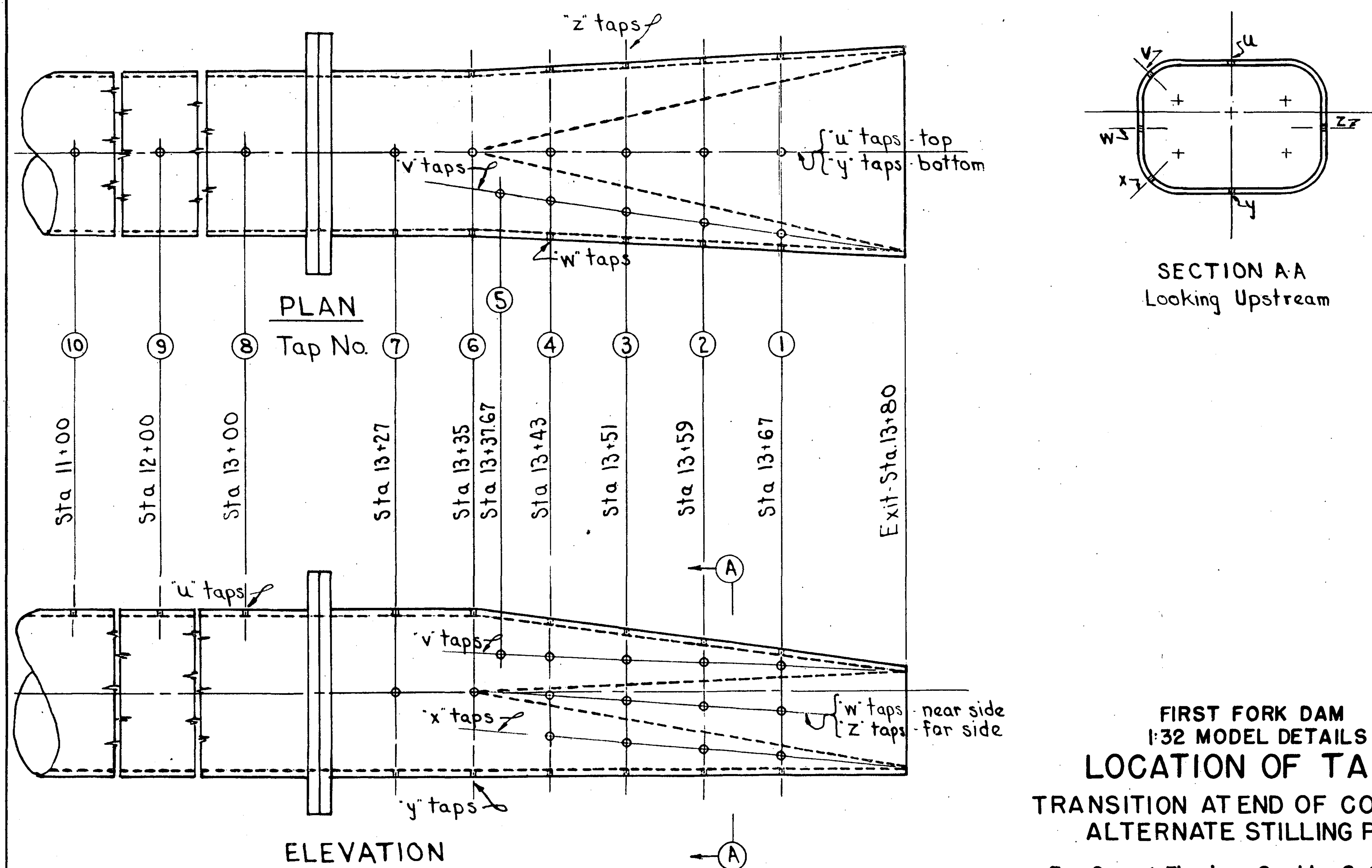
TABLE - TAILWATER ELEVATIONS

From
C.F.C.C.
(C.W.P. - 9/15/52)

TAILWATER DISCHARGE	TAILWATER ELEVATION
2,000 c.f.s.	888.3 Feet
4,000	889.4
6,000	890.4
8,000	891.3
10,000	891.9
11,000	892.1
12,000	892.3
13,000	892.5
20,000	894.2
40,000	898.5
60,000	902.3
80,000	905.8
100,000	908.8
115,000	911.0

- -

FIGURE A-29

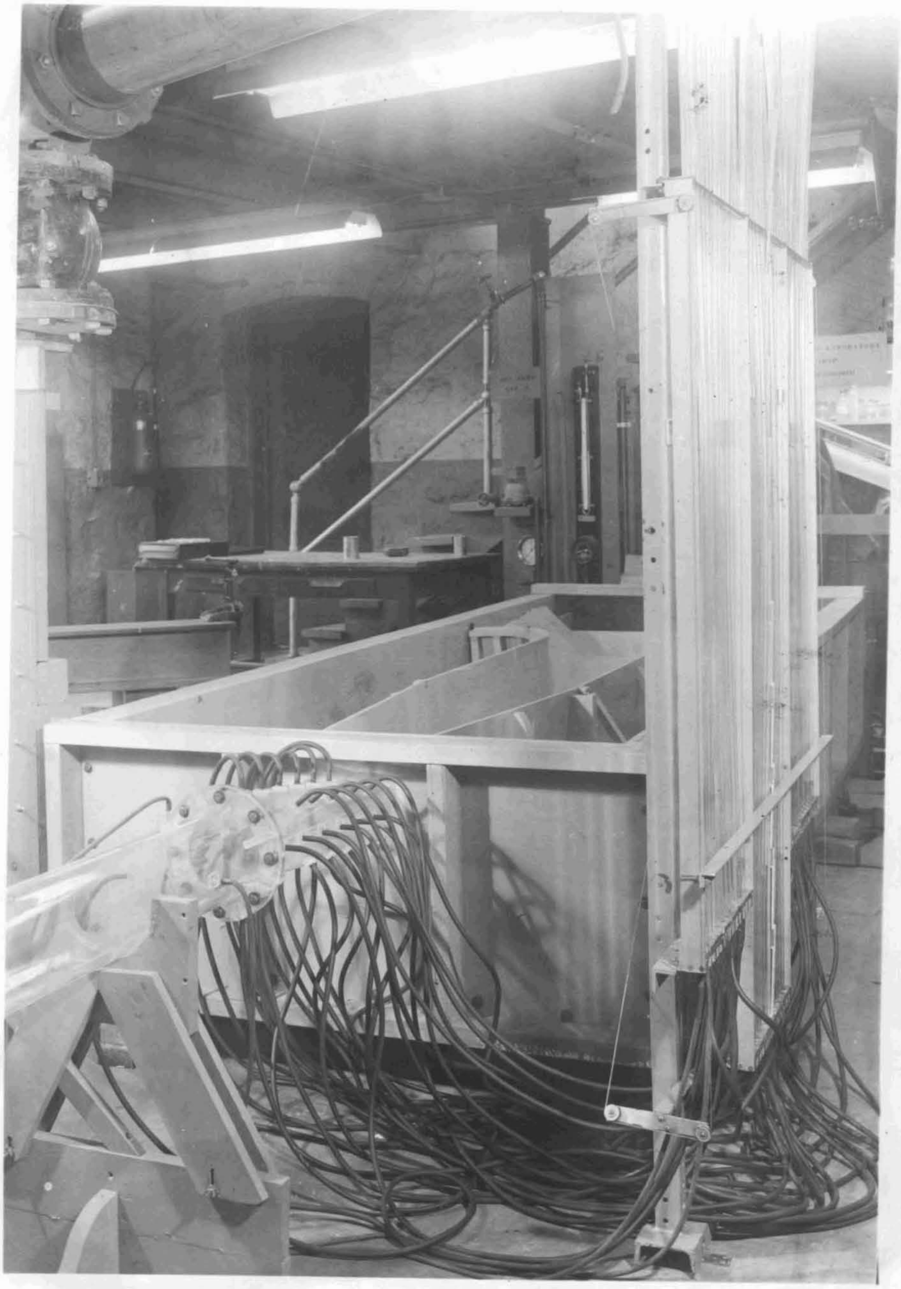


FIRST FORK DAM
1:32 MODEL DETAILS

LOCATION OF TAPS

TRANSITION AT END OF CONDUIT
ALTERNATE STILLING POOL

For Gannet Fleming Corddry & Carpenter
Hydraulic Laboratory Lehigh University
SCALE: $\frac{3}{32}$=1'-0" OCT. 15, 1952 CT 51 B



PHOTOGRAPH SHOWING EXIT
TRANSITION

CT-51-B

Figure A-31

All data given in terms of prototype values - See Fig. A-29 for positions.

First Fork Outlet Structures 1:32 Model Test Data
15 October 1952

EXIT TRANSITION PRESSURE DATA

Tap No.	Elevation	Pressure Head Relative to Given Elevation of Tap 6000 cfs.	8000 cfs.	10,000 cfs.	13,000 cfs.
U-1	893.5	0.6	3.2	6.3	10.8
-2	894.1	-0.3	1.7	5.8	9.9
-3	895.3	-1.8	-0.1	4.3	8.1
-4	896.5	-3.7	-1.7	1.8	4.7
-6	897.3	-5.2	-2.2	0.9	4.1
-7	897.4	-5.5	-5.1	-2.6	2.0
-8	897.6	-6.0	-5.7	-4.1	-2.2
V-1	892.2	1.3	3.2	7.4	11.8
-2	892.9	0.9	2.6	6.8	11.1
-3	893.7	-0.5	2.4	4.9	9.4
-4	894.5	-2.0	-0.7	2.2	5.3
-5	895.0	-3.1	-2.5	-0.2	1.7
W-1	887.0	6.2	8.1	12.2	16.1
-2	887.6	5.9	7.8	11.6	16.2
-3	889.2	4.0	5.8	9.4	13.6
-4	888.8	3.4	4.7	7.6	10.4
-6	889.3	0.9	0.6	1.0	-0.3
-7	889.4	0.8	2.2	3.8	4.4
-8	889.6	2.0	2.3	3.9	4.5
X-1	881.8	11.7	13.6	17.4	21.3
-2	882.3	11.2	13.5	17.3	21.2
-3	882.7	10.8	12.4	15.9	19.7
-4	883.2	9.3	10.3	12.8	15.7
Y-1	881.1	11.7	14.0	17.2	20.7
-2	881.2	11.0	14.2	18.4	22.6
-3	881.2	10.9	13.9	17.7	21.2
-4	881.3	10.9	11.9	15.1	17.6
-6	881.3	9.6	9.9	11.2	11.2
-7	881.4	8.9	9.8	11.1	11.8
-8	881.6	10.0	10.6	12.2	12.8
-9	882.4	9.6	11.3	13.4	16.1
-10	883.1	9.9	11.5	14.4	17.6
Z-1	887.0	5.9	7.5	11.6	15.5
-2	887.6	6.2	8.1	12.6	17.4
-3	888.2	5.3	6.9	10.7	13.3
-4	888.8	3.7	4.7	6.9	10.1
-6	889.3	1.6	1.6	2.6	2.9
-8	889.6	2.0	2.6	4.2	5.2